TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

VOL. 61.
(QUARTERLY ISSUE)
Part 1, MARCH, 1930

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD
OF GOVERNORS OF THE INSTITUTE

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PART 1. MARCH, 1930.

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PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE,

1930.

MINUTES OF ANNUAL MEETING OF THE BOARD OF GOVERNORS,

30th JANUARY, 1930.

THE Annual Meeting of the Board of Governors was held on Thursday, 30th January, 1930, at 10 a.m., in the Biology Lecture Hall, Victoria University College, Wellington.

Present: Representing the Government—Dr. L. Cockayne, Dr. E. Marsden, Messrs. B. C. Aston and W. R. B. Oliver; representing Auckland Institute—Professors H. W. Segar and F. P. Worley; representing Wellington Philosophical Society—Mr. G. V. Hudson; representing Philosophical Institute of Canterbury—Dr. C. Coleridge Farr and Mr. A. M. Wright; representing Otago Institute—Hon. G. M. Thomson and Professor J. Park; representing Manawatu Philosophical Society—Mr. M. A. Eliott; representing Nelson Institute—Professor T. H. Easterfield.

Apologies for absence were received from Professor H. B. Kirk (Wellington Philosophical Society) and Mr. W. H. Guthrie-Smith (Hawkes Bay Philosophical Institute).

Presidential Address: The President, Dr. C. Coleridge Farr, at the commencement of his address, asked the Board to stand in respect to the memory of Dr. Charles Chilton, late Government representative on the Board; also to Captain Bollons, Sir Baldwin Spencer, F.R.S., Dr. Geoffrey Duffield and Captain Ault of the Research ship "Carnegie." At the conclusion of Dr. Farr's address, Dr. Cockayne moved a very hearty vote of thanks to Dr. Farr and asked him that he allow his address to be published in the *Transactions.*

Notices of Motion were then called for.

Fellowship Election: The election for two Fellows resulted in Dr. W. P. Evans and Mr. A. Philpott being elected.

Fellowship, 1931: On the motion of Dr. Cockayne, seconded by Mr. Hudson, it was resolved that two Fellows be elected in 1931.

Hector Award: The Hector Award Committee, Dr. L. Cockayne and the Hon. G. M. Thomson, recommended "That the awa

made to the Rev. Dr. John Holloway, F.N.Z.Inst., for researches destined to become classical—on the Prothallus and young plant of Tmesipterus and on his producing artificially and studying carefully the Protnalli of certain Hymenophyllacae.''—Carried by acclamation.

Amount of Hector Prize: It was resolved that the amount of the Hector Prize for 1930 be £60.

Honorary Membership: Dr. J. Schmidt was elected an Honorary Member.

Incorporated Societies' Reports and Balance Sheets were laid on the table as follows:—Auckland Institute, Wellington Philosophical Society, Philosophical Institute of Canterbury, Otago Institute, Nelson Institute.

Report of the Standing Committee for the Year ending 31st December, 1929.

Meetings: During the year six meetings of the Standing Committee have been held, the attendance being as follows:—Dr. C. Coleridge Farr, President, Christchurch, 6; Mr. B. C. Aston, Wellington, 6; Dr. L. Cockayne, Ngaio, 5; Mr. M. A. Eliott, Palmerston North, 1; Mr. G. V. Hudson, Wellington, 6; Professor H. B. Kirk, Wellington, 4; Mr. W. R. B. Oliver, Wellington, 6; Hon. G. M. Thomson, Dunedin, 2.

The Late Dr. Charles Chilton: It was with the deepest regret that the Standing Committee learned of the death of Dr. Charles Chilton, who was for so long a member of the Board of Governors. At a meeting of the Standing Committee, held on the 6th November, Dr. Farr moved the following resolution which was carried in silence:—

> "That this meeting of the Standing Committee of the New Zealand Institute learns with the greatest regret of the death of Dr. Charles Chilton, D.Sc., LL.D., F.L.S., C.M.Z.S., F.N.Z.Inst., a Hutton Medalist of this Institute and a Mueller Medalist of the Australasian Association for the Advancement of Science, late President of the New Zealand Institute and at the time of his death one of the Board of Governors, and desires to place on record its appreciation of his great services to Science. In that department of learning which he made his principal life study, the Crustacea, he was one of the leading authorities in the world. The Standing Committee realises the loss to science and to the Dominion caused by his death."

This resolution was forwarded to Mrs. Chilton and was also published in the press.

Vacancy on the Board of Governors: On the 6th November the Under-Secretary of Internal Affairs was advised of the death of Dr. Chilton, one of the Government representatives, and informed that the Standing Committee would like to suggest that Dr. Marsden fill the vacancy thus created. On the 16th December the Under-Secretary wrote intimating that Dr. Marsden had been appointed a member of the Board of Governors.

Publications: The final part of Volume 59 of the *Transactions of the N.Z. Institute* was issued in March, the first part of Volume 60 in May, the second part in August, the third part in December and the fourth part will be issued early in 1930.

Parts 2, 3, and 4 of Volume 59 and part 1 of Volume 60 were laid on the table of the House of Representatives on the 18th July, and on the table of the Legislative Council on the 24th July. The later parts are in the hands of the Under-Secretary of Internal Affairs for presentation.

Abstracts: Early in the year the Auckland Institute wrote protesting against the inclusion of abstracts in the *Transactions* and later a similar protest was received from the Otago Institute. In view of the attitude taken up by these societies it was decided at a meeting of the Standing Committee on the 28th March to obtain the opinion of the other incorporated societies on the matter. It was found that the Philosophical Institute of Canterbury was the only one in favour of publishing abstracts in the *Transactions*, and it was therefore decided to discontinue publishing them.

Exchange List: On the recommendation of the Library Committee the following libraries have been added to the Exchange List:—

Royal Zoological Society, New South Wales.
Wanganui Public Library.
University Botanical Museum, Oslo.
Entomological Department of the National Museum, Prague.
Institute for Scientific Exploration of the North, Moscow.
Taihoku Imperial University, Formosa.
Metropolitan Library, Peking.

Partial Sets: Partial sets of the *Transactions* have been presented to the Petone Library and also to the Petone Working Men's Club and Institute.

Library: The Library is growing rapidly and it continues to be used and appreciated by the staff and honours students of Victoria College as well as by members of the Institute. Many volumes have also been posted to members living out of Wellington.

The Institute is deeply indebted to Mr. G. V. Hudson, who generously presented a copy of his valuable book "Butterflies and Moths of New Zealand," to Mr. H. T. Ferrar, who continues to pass on to the Library his Reports of the British Association for the Advancement of Science, and to an Honorary Member, Dr. J. S. Haldane for his book on "Gases and Liquids."

Sales: There has been a considerable increase in the sales for the year largely accounted for by the fact that two complete sets of *Transactions* were sold. The sale of *Transactions* amounted to £98 and Bulletins and Indexes realised £7. One set of Maori Art has also been sold.

Incorporated Societies: The following reports and balance sheets of incorporated societies have been received and are now laid on the table:—

Auckland Institute for the year ending 31st March, 1929.
Wellington Philosophical Society for the year ending 31st October, 1929.
Philosophical Institute of Canterbury for the year ending 31st October, 1929.
Nelson Institute for the year ending 31st October, 1929.
Otago Institute for the year ending 30th November, 1929.

Deputation to the Hon. the Prime Minister: At the last Annual Meeting of the Board the Standing Committee was instructed to arrange a deputation to the Prime Minister with a view to having the New Zealand Institute Act amended. At a meeting of the Standing Committee on the 28th March a sub-committee was set up to consider the required amendments, and it was subsequently decided that the Prime Minister be asked

(1) That the statutory grant be increased;
(2) That the finance clause be again embodied in the Act.
(3) That Section 8 (1) be amended to read "The Annual Meeting of the Board of Governors shall be held after the 31st March in each year, the date and place may be fixed at the previous annual meeting."

The Prime Minister met the deputation on the 12th June. The speakers placed before him the required amendments, explaining the necessity for them and asked, too, that the Institute's debt to the Government Printer be wiped out or considerably reduced. Sir Joseph Ward promised that the Act

would be amended to allow of the alteration of the date of the annual meeting and that he would look carefully into the other matters dealt with. On the 16th August he replied to the effect that it was not considered desirable from the point of view of financial control to transfer the clause in the Finance Act to the Institute's own Act; that the request for an increased grant could not be considered then, nor could he hold out any hope for an increased grant in the immediate future; that the request regarding the date of the annual meeting had been noted for consideration when an amendment of the Act is being dealt with, and that he regretted he could not see his way to agree to the Institute's debt to the Government Printer being written off.

A further endeavour was made to induce the Prime Minister to bring down during the Session the amending bill for the change of date of the annual meeting, but this proved unsuccessful.

Hector Award: At a largely attended meeting of the Otago Institute, held on the 18th June, the Hector Medal was presented to the Hon. G. M. Thomson, M.L.C., by the Hon. T. K. Sidey, M.L.C., and Chancellor of the Otago University. Mr. Sidey outlined the work of Sir James Hector in the cause of science in New Zealand, and after referring to the names of those to whom the medal had previously been awarded, spoke of the researches in zoology and botany carried out in New Zealand by the Hon. G. M. Thomson.

Hutton Award: At a special general meeting of the Wellington Philosophical Society, held in aid of the Earthquake Fund on the 10th July, opportunity was taken to present the Hutton Medal to Mr. G. V. Hudson. In the unavoidable absence of the President of the Institute, Dr. Farr, the President of the Wellington Philosophical Society, Mr. W. R. B. Oliver, made the presentation.

Darwin Medal: At last Annual Meeting it was suggested that, provided the Royal Society was willing, the Darwin Medal should be presented to Dr. L. Cockayne at some public function. It was ascertained that the Royal Society had no objection to this being done and the Philosophical Institute of Canterbury, of which Dr. Cockayne is a Life Member, undertook to arrange for the presentation. A most successful function was held in Christchurch on the 7th August, when Dr. Farr presented the Darwin Medal to Dr. Cockayne.

Fellowship New Zealand Institute: On the 21st March, Drs. G. H. Cunningham and J. Henderson were gazetted Fellows of the New Zealand Institute. Ten nominations for the 1930 Fellowship were received from incorporated societies and were submitted to the Fellows for selection. The result of the selection reported by the Honorary Returning Officer was submitted to the members of the Board of Governors on the 18th October.

National Research Council: The report of the sub-committee which was discussed at last Annual Meeting was referred back to the incorporated societies for report. These reports came to hand and were referred to the sub-committee, Dr. Farr and Mr. A. M. Wright, for consideration. The matter will come up again at the Annual Meeting.

Research Grants: The total amount voted this year by the Government towards the Institute's research grants was £750, leaving a very limited amount for new applications. The applications for new grants received amounted to nearly £900. Eight grants for £172 were approved and two more for £200 are still under consideration.

(The two grants referred to have since been approved).

Honorary Members: One vacancy in the Honorary Membership was declared at last Annual Meeting. Four nominations to fill this vacancy were received and the election will take place at the Annual Meeting.

Pacific Science Congress: At a meeting of the Standing Committee on the 12th February, Dr. J. S. Maclaurin was elected the Institute's representative on the Pacific Science Congress Council. On the 28th March, Dr. P.

Marshall was also appointed to represent the Institute at the Fourth Congress held this year at Java. The reports of these two representatives will be presented at the Annual Meeting of the Board.

Carter Bequest: At a meeting of the Standing Committee on the 12th February, it was resolved that legislative sanction be sought for any contemplated diversion of the Carter Bequest, and that the approval of a meeting of the New Zealand Institute Board of Governors be obtained before any moneys are paid over. At the next meeting of the Standing Committee a sub-committee of four members of the Standing Committee was set up to deal with the above resolution. This committee has not yet reported any action.

T. K. Sidey Summertime Fund: In January last a telegram was received by Dr. Benham from the Hon. T. K. Sidey, M.L.C., as follows: "When Summer Time Act, 1927, was passed a shilling subscription Commemoration Fund was raised, amounting to several hundred pounds. It is proposed that interest of fund be applied to award medal and monetary prize for best contribution on subject of light in relation to human welfare. Medal to be awarded at intervals of some years so that accumulation of income may provide a fair monetary gift, ten per cent. of income to be added annually to capital and say one per cent. deducted for administrative expenses. Can you ascertain whether New Zealand Institute would accept money and undertake administration of fund? If so, I shall ask Summer Time Committee to communicate with Council of Institute."

(Signed) T. K. SIDEY.

Dr. Benham placed this telegram before the Institute and a special meeting of the Board was held in Auckland on the 25th January, when it was agreed to accept the administration of the fund along the lines suggested. On the 22nd July the Honorary Secretary of the Summer Time Appreciation Fund forwarded to the Secretary of the Institute a cheque for £500, being the balance of the fund, and subsequently the Standing Committee set up a sub-committee to draw up regulations with the Hon. T. K. Sidey. On the 6th November this committee reported that the proposed regulations and Deed of Trust had been drawn up and had been submitted to Mr. Sidey for his approval. These regulations will be finally submitted to the Board of Governors at the Annual Meeting for adoption.

Science Congress, 1929: Seven resolutions passed at the Science Congress in Auckland were forwarded to the Institute and were dealt with at meetings of the Standing Committee held on the 12th February and 28th March as follows:—

1. That the General Committee of the Science Congress approves of the committee set up by the Biology Section to further nature study in schools, and recommends that it be appointed as a committee of the Institute to co-operate with the Education Department in promoting nature study and natural science in the primary and post-primary schools. The personnel of the committee to be Rev. Dr. Holloway, Dr. L. Cockayne, Mr. R. A. Falla and the Hon. G. M. Thomson.

This resolution was confirmed by the Standing Committee.

2. That it be recommended that at future congresses, if sufficient papers are sent in in any of the subjects grouped in one section in this Congress, these sections be divided into appropriate parts.

This resolution was not confirmed.

3. That the Secretary of the Congress be directed to advise the authors of papers that the *Transactions of the New Zealand Institute*, the *N.Z. Journal of Science & Technology* and the *Polynesian Journal* will be prepared to consider for publication any papers read at the Science Congress.

This resolution was confirmed.

4. That it be a recommendation to the Secretary of the next Congress that a list of all papers to be read at the Congress be circulated to intending members as far in advance as possible to facilitate preparation of discussion.

This resolution was confirmed.

5. That the General Committee of the Science Congress records its thanks, particularly on behalf of the Auckland members, to Mr. Archey and his staff for the efficient manner in which all matters in connection with the Congress were arranged and that Mr. Archey be asked to convey this expression of the committee's appreciation of their efforts to the members of the Institute and Museum staffs.

This was very heartily endorsed by the Standing Committee.

6. A resolution passed by the Economics and Social Science Section and forwarded by its secretary to the Prime Minister and to the Hon. Minister of Health as follows: "That in view of recent cases more adequate safeguards against the improper committal of persons to mental hospitals should be provided by means of a revision of existing law and practice," was not endorsed by the General Committee of the Congress, and the Standing Committee resolved that the matter of representation to the Government by Science Congress meetings be discussed at next Annual Meeting.

7. A resolution passed by the Anthropological and History Section of the Congress and approved by the General Committee was as follows:—

That the Anthropology and History Section of the Congress urges the New Zealand Institute to devise some means for enlisting the sympathy of suitable persons in the project of collecting material for an archaeological survey of New Zealand. It further suggests that the Institute should approach the Government and ask (1) That assistance be given to the project and (2) That legislation be passed in order that sites likely to be of value for this purpose be protected from unauthorised and unqualified persons.

The Standing Committee, after discussing this resolution, asked Mr. Oliver to report on the subject at next meeting. Mr. Oliver, in his report at the following meeting, outlined the action that the late Dr. Allan Thomson had previously taken in the matter.

The President of the N.Z. Tourist League wrote to enlist the sympathy of the New Zealand Institute in an endeavour "to preserve the National Monuments of New Zealand by the formation of a National Park Conservation Board which it was hoped would particularly supplement the good work which had been done for many years by the Scenery Preservation Commissioners in the purchase and reservation of bush and scenic areas." The subject was discussed at several meetings of the Standing Committee and on the 25th September it was finally resolved to refer the subject of Scenery Preservation to the Annual Meeting of the Board and that a committee should then be set up.

Rainbow Mountain: At a meeting of the Standing Committee on the 28th March it was reported that there was a movement on foot to destroy the shrubs and growth on Rainbow Mountain, and Dr. Cockayne was asked to draft a letter of protest to the Hon. Minister in charge of scenery preservation, who replied as follows: ". . . . Representations have been made to my Department that steps should be taken to clear the slopes of Rainbow Mountain of teatree and fern in order that tourists might view the full beauty of the mountain; but it is felt that it would not be desirable to take any steps that might result in the burning of the vegetation. It is considered that the mountain should be left in its present condition and the vegetation allowed to flourish even if certain areas of coloured soil and rocks are thereby somewhat obscured. It is of course possible that further representations may be made on the lines of those already submitted; but you may be assured that my Department would not recommend the taking of any action to clear the growth without giving the fullest possible consideration to all

aspects of the question and without becoming convinced that such action was not only practicable but also necessary in the best interests of the reserve."

Dominion Museum: Early in the year an effort was made to have the New Zealand Institute represented on the Board of Trustees of the Dominion Museum, and the Chairman of the Board was written to on the matter. On the 29th April the acting-Hon. Secretary replied that the matter would be further discussed at the next meeting of the Board of Trustees. No further communication has been received.

On the 25th September, Mr. Oliver, Director of the Dominion Museum, reported as to the provision which had been made in the estimated space for the New Zealand Institute in the plans of the new Museum. He also stated that the Dominion Museum was being inequitably treated in the proposed allocation of cost of the new buildings in that the allocation suggested as between the Museum and Art Gallery was not that originally intended, and he urged the Institute to assist with other interested bodies in an attempt to have the original allocation adhered to. On the 6th November the Hon. G. M. Thomson again brought up the matter of the allocation between the Museum and Art Gallery and read some correspondence between himself and the Mayor of Wellington. After some discussion it was resolved that a sub-committee consisting of Mr. Oliver, Hon. G. M. Thomson and Dr. Marsden be set up to obtain all the facts and information regarding the recent history of the scheme and to organise a conference with the Mayor. This conference has not yet been arranged.

Scientific Survey of Native Birds: The Secretary of the Nelson Bush and Bird Preservation Society forwarded on the 11th April the following resolution:—"That this Society strongly urges that a well-organised scientific survey of the habits of the native birds of New Zealand be carried out with as little delay as possible, and that in this matter the interested societies, such as the N.Z. Acclimatisation Society, N.Z. Forestry League, N.Z. Native Bird Protection Society and the New Zealand Institute, should provide the necessary finance, subsidised by the Government."

It was decided to refer the above resolution to the Annual Meeting and that the Nelson Society should be asked what proposed organisation it would consider necessary and the probable expenses of such a survey. This information has not yet been supplied.

Destruction of Shags: The Standing Committee resolved to support Mr. E. F. Stead, of Christchurch, in his endeavour to have the shag protected, and at a meeting of the Standing Committee, held on the 25th September, it was decided to write to the Marine Department endorsing Mr. Stead's action.

Former Honorary Editor: On the 12th June a letter was received from the Wellington Philosophical Society suggesting that the services of the former Editor, Mr. J. C. Andersen, be recognised in some tangible manner and that incorporated societies and the New Zealand Institute contribute sufficient to enable Mr. Andersen to become a life member of one of the societies. At a subsequent meeting it was resolved that a substantial presentation be made to Mr. Andersen for the valuable services he had rendered to the Institute as Honorary Editor and that incorporated societies be asked to open subscription lists, and that the matter be then referred to the Annual Meeting.

Solar Eclipse: At a meeting of the Standing Committee on the 6th November a letter was received from the Wellington Philosophical Society asking that the New Zealand Institute support Dr. C. E. Adams in an application for loan of instruments to observe the solar eclipse of October, 1930. It was resolved to assist Dr. Adams as far as possible.

London Agency: Messrs. Wheldon & Wosley Ltd., having indicated that they wish to relinquish the agency of the New Zealand Institute in London, it was decided that Mr. N. Wright, of the High Commissioner's Office, be asked to make enquiries regarding a new agency.

Carter Legacy: On an undertaking from the Institute that the Carter Legacy would not be withdrawn for at least a further five years, the Public Trustee agreed to allow 5½% interest on the amount.

Scientific Survey of the New Zealand Coast: Early in the year an effort was made by the Hon. G. M. Thomson, supported by the President of the Institute, to induce the Government to employ the U.S. Barque "City of New York" of the Byrd Expedition, which was then lying idle at Port Chalmers, and would be there for many months, in a scientific survey of the coasts of New Zealand. A representative committee was set up and it agreed on certain lines of action in the proposed survey. However, the scheme fell through as the Government considered it would involve too great an expense which the results would not justify, and Commander Byrd also was afraid of taking any risks with his relief ship and so imperil the success of his Expedition.

Standing Committee's Report: The report of the Standing Committee was considered clause by clause and adopted.

Arising therefrom:

Science Congress Resolutions: On the motion of Dr. Marsden it was resolved "That any resolution passed at any Science Congress be forwarded to the Standing Committee for approval and transmission to the Government if approved."

Nature Study in Schools: Dr. Cockayne reported what action the committee set up to further nature study in schools had taken, and after some discussion it was resolved, on the motion of Professor Worley, seconded by Dr. Marsden, "That the Academic Board and the Entrance Board of the University of New Zealand be requested to consider the possibility of modifying the syllabus for the University Entrance Examination and the syllabus of the University Entrance Scholarship in such a way as to encourage the study in schools of natural history in its original sense."

On the motion of Professor Easterfield, seconded by Dr. Cockayne, it was resolved "That the Board of Governors suggests to the Minister of Education that inasmuch as the New Zealand Institute stands in a similar relationship to science in New Zealand to that in which the Royal Society stands to science in Great Britain, it would be in the interest of education in New Zealand if the New Zealand Institute were officially consulted in connection with any proposed changes in the science teaching in primary and post primary schools."

Scientific Survey of Native Birds: It was resolved that the Standing Committee deal with this matter after the Nelson Bird and Bush Society had supplied the information required.

Presentation to Former Hon. Editor: It was resolved that the matter be left in the hands of the Standing Committee for action.

Hon. Treasurer's Report.

The Balance Sheet for the year ending 31st December, 1929, shows a debit balance of £287/19/8, which amount, however, includes a debit balance of £249/6/4 brought forward from the previous year.

The amount due to the Government Printer has been reduced from £877/0/9 to £521/9/7, the balance still owing has been swelled by the inclusion of £198/2/3 interest debited during the past four years. The amount charged by the Government Printer for Volume 56 was £1610/15/5. Under the new arrangements with a private publishing firm, Volume 57 cost £1316/10/0, Volume 58 (in four parts) £839/7/3, Volume 59 (in four parts) £1432/18/0, and Parts 1 and 2 of Volume 60 £484/6/4. The high cost of Volume 59 was due to Part 4 costing £510/9/9—about double the amount of any other part. All liabilities for printing up to and including Part 2 of Volume 60 have been paid and in addition £400 has been paid to the Government Printer in reduction of his old account.

Outstanding Accounts: A special effort should be made to collect these, as one in particular has been owing for over five years.

Trust Accounts: The Carter Bequest Capital Account now stands at £7556/8/8, showing an increase of £400 over the previous year.

The Hutton Memorial Fund Capital Account also shows an increase from £1114 to £1214, and the other Trust Accounts remain in a satisfactory condition.

We have been entrusted with a new fund, viz., the T. K. Sidey Summer Time Fund, of £500. This amount will be invested in approved securities and the interest derived used as a Prize Fund.

We will have the above amount, together with about £500 from the various Trust Revenue Accounts to invest this month, and I consider that we should purchase the new issue of Government Bonds bearing interest at 5½ %.

I desire to once again compliment the Assistant-Secretary on the manner in which the books and accounts have been kept.

(Signed) M. A. Eliott,
Honorary Treasurer.

NEW ZEALAND INSTITUTE.

Statement of Receipts and Expenditure for the Year ending 31st December, 1929.

Receipts.

	£	s.	d.
Balance as at 31st December, 1928	1443	8	5
Statutory Grant	1500	0	0
Levy, Volume 59, Trans. N.Z. Inst.	186	15	0
Sales of Publications	64	8	10
Author's corrections paid	3	15	6
Research Grants from Treasury, etc.	707	7	4
T. K. Sidey Summer Time Fund	500	0	0
Donations, Presentation late Hon. Editor	3	2	6
Interest, Post Office Savings Bank	43	1	6
Carter Bequest Interest	404	13	8
Hutton Memorial Fund Interest	68	6	4
Hector Memorial Fund Interest	68	12	6
Carter Library Legacy Interest	8	0	0
Endowment Fund Interest	23	3	7
Transfer to B.N.Z. from Hector Fund Account	2	17	7
	£5027	12	9

Expenditure.

	£	s.	d.
Ferguson & Osborn Ltd. (Printing)	1372	7	10
Government Printer (On Account)	400	0	0
Stationery, etc.	8	6	8
Travelling Expenses	64	13	7
Salary	300	0	0
Charges	10	16	6
Petty Cash	17	6	10
Research Grant Instalments	665	15	8
Hutton Research Grants	33	2	7
Hector Award Prize	55	0	0
Hector Medals and Duty	16	10	1
Carter Bequest Reinvested	400	0	0
Trust Funds transferred to Accounts	47	17	5
Balance as under	1635	15	7
	£5027	12	9

	£	s.	d.	£	s.	d.
Balance in Bank New Zealand	306	15	1			
Less Unpresented Cheques	27	1	0			
				279	14	1
Balance in Post Office Savings Bank				1353	14	11
Petty Cash in Hand				2	6	7
				£1635	15	7

The Audit Office, having examined the Balance Sheet and accompanying Accounts, required by law to be audited, hereby certifies them to be correct.

G. F. C. Campbell,
Controller and Auditor-General.

NEW ZEALAND INSTITUTE.

REVENUE ACCOUNT FOR THE YEAR ENDING 31ST DECEMBER, 1929.

Expenditure.

	£	s.	d.
Balance as at 31st December, 1928	249	6	4
Printing and Stationery	1424	0	10
Salary	300	0	0
Travelling Expenses	64	13	7
Charges (Insurance, Bank, Audit)	10	16	6
Petty Cash	17	6	10
	£2066	4	1

Income.

	£	s.	d.
Statutory Grant	1500	0	0
Sales of Publications and Levy	278	4	5
Balance	287	19	8
	£2066	4	1

To Balance	£287	19	8

NEW ZEALAND INSTITUTE.

Statement of Assets and Liabilities as at 31st December, 1929.

Liabilities.

	£	s.	d.
Carter Bequest Capital Account	7,556	8	8
Hector Memorial Fund Capital Account	1,184	18	1
Hutton Memorial Fund Capital Account	1,214	6	0
Hamilton Memorial Fund Capital Account	56	11	6
Carter Library Legacy Capital Account	100	0	0
Endowment Fund	497	17	0
T. K. Sidey Summer Time Fund	500	0	0
Carter Bequest Revenue Account	65	6	0
Hector Memorial Fund Revenue Account	64	1	9
Hutton Memorial Fund Revenue Account	157	2	6
Hamilton Memorial Fund Revenue Account	2	19	9
Carter Library Legacy Revenue Account	34	13	2
Endowment Fund Revenue Account	165	14	6
Library Fund	176	19	4
Research Grant Fund	649	4	9
Government Printer	521	9	7
Faxon & Co. Ltd.	1	3	10
Contributions, Presentation late Hon. Ed.	3	2	6
	£12,951	18	11

Assets.

	£	s.	d.	£	s.	d.
Inscribed Stock				8,418	2	11
P.O. Inscribed Stock				2,135	6	10
Bank New Zealand	306	15	1			
Less Unpresented Cheques	27	1	0			
				279	14	1
Post Office Savings Bank				1,353	14	11
Petty Cash in Hand				2	6	7
Outstanding Accounts				93	19	3
Carter Bequest P.O.S.B. Account				65	6	0
Hector Memorial Fund P.O.S.B. Account				64	1	9
Hutton Memorial Fund P.O.S.B. Account				157	2	6
Hamilton Memorial Fund P.O.S.B. Account				59	11	3
Carter Library Legacy P.O.S.B. Account				34	13	2
Balance of Liabilities over Assets				287	19	8
				£12,951	18	11

NEW ZEALAND INSTITUTE.

Trust Accounts.

Carter Bequest for the Year ending 31st December, 1929.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Interest Reinvested	400	0	0	By Balance, 31/12/28	59	9	9
„ Balance	65	6	0	„ Interest ..	405	16	3
	£465	6	0		£465	6	0
				By Balance . ..	£65	6	0

Hector Memorial Fund for the Year ending 31st December, 1929.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Prize	55	0	0	By Balance, 31/12/28 ..	64	18	11
„ Medals and Duty ...	16	10	1	„ Interest	70	12	11
„ Balance ..	64	1	9				
	£135	11	10		£135	11	10
				By Balance ..	£64	1	9

Hutton Memorial Fund for the Year ending 31st December, 1929.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Research Grants	33	2	7	By Balance, 31/12/28 .	118	14	4
„ Balance	157	2	6	„ Interest	71	10	9
	£190	5	1		£190	5	1
				By Balance	£157	2	6

Hamilton Memorial Fund for the Year ending 31st December, 1929.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Half Interest to Capital Account	1	2	9	By Balance, 31/12/28	1	16	11
„ Balance	2	19	9	„ Interest	2	5	7
	£4	2	6		£4	2	6
				By Balance	£2	19	9

Carter Library Legacy for the Year ending 31st December, 1929.

Cr.	£	s.	d.
By Balance, 31/12/28	25	18	0
„ Interest	8	15	2
„ Balance	£34	13	2

T. K. Sidey Summer Time Fund for the Year ending 31st December, 1929.

Cr.

	£	s.	d.
By Cheque from Summer Time Appreciation Committee	500	0	0
	£500	0	0

Carter Library Legacy.—Public Trustee's Account for the Year ending 31st December, 1929.

	£	s.	d.
Residuary Capital Account	50	0	0

Receipts.	£	s.	d.	*Disbursements.*	£	s.	d.
Interest, Public Trust Office:				Beneficiary's Account, N.Z. Institute: Cash .	2	11	4
31/12/28 to 17/6/29 at 5%	1	3	0				
17/6/29 to 31/12/29 at 5¼%	1	8	4				
	£2	11	4		£2	11	4

Asset.	£	s.	d.	*Liability.*	£	s.	d.
Cash as per Capital A/c. .. .	50	0	0	Donation (payable when conditions in will are complied with)	50	0	0
	£50	0	0		£50	0	0

Certified by Public Trust Office,
Masterton, 13/1/30.

Hon. Treasurer's Report and Balance Sheet: The Hon. Treasurer moved the adoption of his report and balance sheet.

On the motion of Professor Park, seconded by Professor Worley, it was resolved that the Hon. Treasurer and Hon Secretary take the necessary action to collect overdue accounts.

Report of the Research Grant Committee.

On the assumption that the usual amount of £1000 would be voted for research, applications for grants were invited in May.

Thirteen applications were received for amounts totalling £890: 10: 0. The Research Committee met in August to consider these applications and it was then notified by the Department of Scientific and Industrial Research that only £750 had been voted to cover existing grants and any new ones.

This made it necessary to restrict the granting of new applications. Accordingly only ten applications for curtailed grants, amounting to £202, were approved.

The Committee desires to place on record its deep regret at the death of its Chairman, Dr. Charles Chilton, who passed away in October.

Reports of the year's work have been received from most of the grantees, and these have been abstracted by the Assistant Secretary.

(Signed) C. Coleridge Farr,
Acting Chairman.

Research Grants Committee Report: On the motion of the acting Chairman of this committee, Dr. C. C. Farr, this report was adopted.

Dr. Marsden explained the position in regard to the reduced amount voted for the Institute's research grants.

Report of the Research Grantees for the Year ending 31st December, 1929.

Dr. C. E. Adams who, in 1925, was granted £200 for a research on Southern Stars and who requires an interferometer for this purpose, has now received advice from London that the interferometer could not be built for £200 and that £500 would be required. He is making further enquiries regarding the cost. None of the grant has been expended.

Mr. G. Archey who, in 1926, was granted £40 for the study of new species of N.Z. Centipedes and Millipedes, reported on 23rd December that, owing to the work entailed in connection with the removal to the new Auckland Museum, it has not been possible to do any work in his research. He proposes, however, to continue collecting this season.

He has a balance in hand of £7/13/6.

Mr. B. C. Aston who, in 1928, took over the balance of Dr. Malcolm's grant, £9/16/7, for research on pukateine, reported on 22nd November that supplies of the bark of pukatea have been sent to Professor Barger of Edinburgh, who is investigating the constituents of the contained alkaloids, and to Dr. Fogg, a student of Otago Medical School, who is going to do post-graduate work in America, and whose investigation will deal with the physiological action of pukateine.

The Institute has a balance of £6 in this grant.

Professor W. N. Benson who, in 1925, was granted £50 for preparing rock sections, reported on the 9th November that he had continued detailed mapping of parts of the Dunedin district. Microscope sections formerly paid for out of the grant were now being made in the University. Expenses amounted to £4, which leaves a balance of £27/5/0 in hands of the Institute.

Mr. A. E. Brookes who, in 1928, was granted £40 for the study of Coleoptera, reported on the 25th November that a ten-drawer insect cabinet had been imported from England for his specimens. It is proposed to spend several weeks on field work at Great Barrier Island during January.

The Institute has a balance of £30 in this grant.

Dr. K. M. Curtis who, in 1928, was granted £50 for the control of Black Rot in Hops, reported on the 1st December that laboratory work and field tests had been carried out, the latter comprising eleven methods of treatment in six hop fields applied in October and early November. Two records of treated and control hills have been taken, one prior to the treatment and the other in late November. Three more will be taken during the season and the experiments will run for about three years.

Expenditure has amounted to £45/2/4.

Mr. W. C. Davies who, in 1921, was granted £50 for research on soil bacteria, reported on 24th December that further progress has been made during the year, work being carried out on the soils of the mud flat reclamation at Wakapuaka in connection with chemical anlyses by the agricultural staff of the Cawthron Institute. The whole of the grant has been expended.

Dr. H. G. Denham who, in 1928, was granted £75 for research on essential oils of *Pinus Insignus*, reported on the 26th November that Mr. T. H. McCombs, a National Research scholar, has been engaged during the past nine months on the work, and he forwarded a copy of his thesis, entitled

"An Examination of Essential Oils (Turpentina from *Pinus radiata* (insignus) and *Pinus pinaster* (Maritima))."

The expenditure amounts to £41/18/2 and the balance is in the hands of the Registrar of Canterbury College for disbursement.

Dr. W. P. Evans who, in 1929, was granted £35 for work on the microstructure of N.Z. Lignites, reported on the 23rd December that work upon the evidently altered lignites has been completed. Some crushed stems from Otago are now being dealt with in detail. A Leitz grinder, complete, and 0 3 h.p. inductor motor have been purchased. One paper has been published in the *Journal of Science & Technology* and the final article on the altered lignites is in type.

Expenditure amounts to £27/9/7, the Institute holding the balance.

Professor T. H. Easterfield who, between 1921 and 1926, was granted £100 for research on orchard fruits, reported on 24th December that the whole of the grant had been expended and during the last two years additional funds have been supplied from the Department of Scientific and Industrial Research. The results of the work will shortly be issued in the form of a Bulletin.

Dr. C. Coleridge Farr who, in 1921, was granted £15 for research on the physical properties of gas free sulphur, reported on the 23rd November that he and Mr. McLeod are making a determination on the latent heat of gas free sulphur, values of which by various experiments vary greatly. A successful determination has already been made but further work is necessary to confirm it. There has been no expenditure and the Institute holds a balance of £4/18/1.

Professor D. C. H. Florance, who, in 1928, was granted £38 and in 1929 an additional £20 for oscillation crystals and supersonic waves, reported on the 2nd December that the apparatus incorporating a crystal oscillator as used by the research worker, Mr. F. G. White, has been modified so that measurements might be made of the velocity of sound waves of high frequency in mixtures of air and carbon dioxide. The effect of humidity and also of any departure from the plane wave condition on the measured velocity of sound was investigated. It is intended to measure the velocity of high frequency sound waves in ionised gases.

The largest crystal was used in an investigation of the nodal patterns on the surface of the oscillating crystal. A preliminary account of the work was published in the Philosophical Magazine and further accounts have been prepared.

Expenditure amounts to £34/9/5.

Dr. Hilgendorf, who, in 1926, was granted £50 for a calculating machine, reported on 23rd November that the machine is being used daily for wheat, pasture, manurial and herd-testing trials and that it is in good order. He also reports that the camera loaned to him in connection with wheat research is in daily use.

Dr. J. K. H. Inglis, who, between 1923 and 1929, has been granted £105 for research on essential oils, reported on 30th November that the researches had been continued during the past year on N.Z. rata, pepper plant, rimu, totara and white pine. The large plant still that has been used for this work has considerably corroded and must be replaced in part by a tinned copper vessel.

The Institute has a balance of £20.

Mr. F. V. Knapp, who, in 1925, was granted £25 for research on Maori Artifacts, reported on 14th December that nothing has been done this year owing to ill health. He leaves for England early next year and will not be able to resume until 1931.

The Institute has in hand a balance of £15/6/0.

Mr. R. M. Laing, who, in 1924, was granted £100 and in 1929 an additional £25 for research on N.Z. Algae, reported on 23rd November that algological collections have been made at various places, and a paper entitled "A Reference List of N.Z. Marine Algae, Supplement 1," has been sent in for publication. This deals chiefly, but not solely, with *Delesseriaceae*. These have been revised by Dr. Kyln of Lund, from a collection sent home by Mr. Laing. A new genus, *Laingia*, has been established, and several new species described.

His paper in the *Transactions* on the N.Z. species of *Gigartina* has led to considerable correspondence with Dr. Hercus of the Otago Medical School, Dr. Holloway and several domestic science instructors, regarding edible seaweeds and their valuable iodine content. Analyses of various species of *Gigartina* have been made by Dr. Hercus, and reports thereon published. A second paper on the foliose forms of N.Z. *Gigartina* will be ready for publication shortly.

The Institute has a balance of £23/15/0.

Mr. A. Philpott, who, in 1928, was granted £40 for research on the Lepidoptera of Mt. Cook district, reported on 21st November that he made one visit to Mt. Cook and collected about 600 specimens covering about 145 species. Beyond a rough sorting no work has been done on the material as another trip is contemplated, when the material will then be worked out and results embodied in a paper.

Expenditure to date is £14/19/4.

Mr. A. W. B. Powell, who, in 1925, was granted £50 for a survey of the molluscan fauna in Manukau Harbour, reported on the 27th November that a paper entitled "New Species of N.Z. Mollusca from Shallow Water Dredgings," Part 1, has been completed and sent in to the Editor. Good progress has been made with the survey of Manukau Harbour fauna and results will probably be completed next year. The balance of the grant will be expended on literature.

The Institute has a balance of £4.

Mr. W. F. Short, who, between 1925 and 1929, was granted £189 for research on the constitution of N.Z. Essential Oils, reported on 30th November that further supplies of the *Sesquiterpene* aromadendrene have been obtained from two eucalyptus oils, namely, those of *E. globulus* and *E. rariflora* and the results of the investigation are being published conjointly with Mr. A. R. Penfold, of the Technological Museum, Sydney, who is examining the low boiling constituents of the oil of *E. rariflora*. Further results in the examination of *Leptospermol* are also being obtained.

There is an unexpended balance of £9/6/10.

Mr. H. F. Skey, who, in 1926, took over from Captain Isitt £36/10/9 and in 1927 was granted an additional £175 for Upper Air research, reported on the 30th November that up to date 50 single pilot balloon flights and two double theodolite flights have been observed. The latter demonstrated the practical reliability of the ascension rate used in computation of the single theodolite flights. They were interrupted by the loan to the Department of Scientific and Industrial Research of a theodolite for work in Auckland. It is a matter for congratulation that upper air currents are now observed in three centres in New Zealand—Christchurch, Auckland and Wellington—and when correlation with the synoptic charts is accomplished, valuable results should emerge.

Mr. Skey will in future be able to carry out the work more systematically and he expects to publish the data of the second 100 flights in Volume 6 of the Records of the Survey of New Zealand.

Professor R. Speight, who, in 1928, was granted £50 for Geological work in Mt. Somers district, reported on 22nd November that examinations carried on as occasion offered had been nearly completed, only two small areas needing investigation. The general stratigraphical problems arising in connection with the geological structure have been fully considered. Analyses of typical and volcanic rocks have been made by the Dominion Laboratory, and a visit paid to the area by the Government Palaeontologist, Dr. J. Mar-

wick. A commencement has been made with the geological mapping of the area, and this has been completed as far as the Clent Hills is concerned.

Grantee has a balance in hand of £24/10/0.

Mr. F. J. Turner, who, in 1928, was granted £100 for a geological expedition to Red Hills country in South Westland, reported on November 28 that this expedition was made with the assistance of Mr. W. E. La Roche, B.Sc., of the Auckland Grammar School, and Mr. G. J. Williams, M.Sc., F.G.S., research student at Otago University, and took from January 5 to February 8. The weather conditions were exceptionally bad, their guide losing two horses in crossing flooded rivers and a third horse being killed in a slip. A paper dealing with the geological features of this area has been completed and will be submitted for publication in the *Transactions*. The whole of the grant was expended.

Dr. G. H. Uttley, who, in 1928, was granted £35 for micrographic apparatus for research on Bryozoa, reported on 1st December that descriptions of new and little known species of Bryozoa (Recent and fossil) have been nearly completed and the work of illustrating these with photographs is being carried on at present. There is a balance of £7.

Professor F. P. Worley, who, in 1923 and 1925, was granted £50 for a research on the chemistry of essential oils, reported on the 21st November that a research on the essential oil of *Melicope ternata* has been completed and the results published in a paper in Volume 60 of the *Transactions*. Institute has in hand a balance of £10/13/0.

No reports have been received from Dr. Allan, Dr. G. H. Cunningham, Mr. Foster, Mr. H. Hamilton, Research Committee of Auckland Institute, Messrs. Wild & Tankersley, and Messrs. Wild & Zotov.

TONGARIRO NATIONAL PARK.

Report of the New Zealand Institute's Representative on Park Board.

The year 1929 will be memorable in the history of the Tongariro National Park for the fact that the arrangements mentioned in my last report (p. 14, Part 1, Volume 60, 1929 *Trans. N.Z. Inst.*) for the erection of an up-to-date hostel in the Park, have been successfully carried out, the building having been erected and thrown open to the public in November last.

The negotiations by which this desirable state of things has been accomplished are largely due to the business ability of the Chairman of the Board, Mr. J. B. Thomson.

In his annual report to Parliament (C. — 13, 1929), Mr. Thomson quotes with approval some words of the Right Hon. Stanley Baldwin to a Welsh audience on St. David's Day, 1927: "You have a beautiful country in Wales. Don't let strangers spoil it for you and don't spoil it yourselves. Educate public opinion, educate your local authorities and bear in mind the example of New Zealand, a new country with a small population, which is already scheduling a magnificent region in the North Island and reserving it for all time as a national park. This is a wise economy of nature."

With such an ideal in view it is to be hoped that there will be no obstacle to prevent the Board from adopting a policy which will preserve the natural features of the Park for all time, secure from desecration by the hands of the tourist, competing species, or exotic animals.

As some 25,000 visitors may be expected to visit the Park annually, there is room for the exercise of considerable supervision by the custodian.

The report is attached; it gives details of the progress made during the year, with a full-paged drawing of the hostel.

Three meetings of the Board or Executive Committee have been held during the year, but the Board's strength has been sadly diminished by the deaths of three most valuable members—Messrs. W. Salt, A. G. Simpson and B. M. Wilson, all active workers for the progress of the Park as a national institution.

(Signed) B. C. Aston.

Tongariro National Park: On the motion of Mr. B. C. Aston, the Institute's representative on the Park Board, the report was adopted. The Hon. G. M. Thomson reported that he had written to the Chairman of the Tongariro National Park Board suggesting certain names recommended by the Standing Committee and had received a sympathetic letter in reply stating that when any future vacancies occurred on the Park Board the wishes of the Institute would be considered.

Great Barrier Reef Committee.

Four meetings were held during the year.

Several reports on the work of the Great Barrier Reef Expedition were submitted by the Leader, Dr. O. M. Yonge, and the other members of the Expedition.

The camp on Low Island was evacuated on July 28th, 1929, being one year and 12 days after the Expedition arrived. Practically all the original programme of the Expedition has been completed, much of it in greater detail than was originally intended. The scientific work accomplished by the Expedition included investigations into the distribution of plankton, tracing the life-history of reef building corals, observations on the effect of sediment on corals, an ecological survey of Low Island, including both the land vegetation and the coral region, an investigation of the breeding seasons of common animals, study of the growth rate of corals and of respiration and photosynthesis in corals and observations on the physical properties of the sea water.

The economic work of the Expedition included investigations into the life-histories of Trochus, Pearl shells, beche-de-mer, oysters and certain fishes.

The marine Biological work on the Barrier Reef initiated by the Expedition will be carried on by the Queensland Government.

Financial Statement, October 18th, 1929.

	£	s.	d.
Receipts	1807	3	2
Expenditure	15	9	9
Balance	£1791	13	5

(Signed) W. R. B. Oliver,
N.Z. Institute Representative,
Great Barrier Reef Committee.

Great Barrier Reef Committee's Report: On the motion of Mr. W. R. B. Oliver, the report was adopted.

Report of the Publication Committee.

A change of Editor took place at the beginning of 1929, Mr. Johannes C. Andersen having found it necessary to relinquish the position after nine years of valuable service.

Volume 59 was completed by the late Editor, Part 4 being issued on 28th March, 1929. It was an exceptionally large volume, consisting of 1024 pages and 120 plates. The papers numbered 55 by 48 authors. Details of the first three parts were given in last year's report. Part 4 contained iv plus 362 plus xii pages, and 43 plates.

For Volume 60, 75 papers by 53 authors were submitted, of which 23 by 10 authors, were either declined, or sent back for revision and not re-submitted. Part 1 contains 204 pages and 17 plates; Part 2, 174 pages and

15 plates; Part 3, 142 pages and 27 plates; being a total for the three parts of 520 pages and 59 plates. Part 4 is in preparation.

A proposal is being considered to divide the editorial work among a small committee according to subjects. It is, of course, impossible for a single Editor to be conversant with all the branches of science represented in the published papers, or to be in touch with all the best authorities who are available as referees.

For the Publication Committee,
(Signed) D. M. Y. Sommerville.

Publication Matters: The report of the Honorary Editor was adopted. Professor Sommerville reported that he would be willing to carry on as Honorary Editor if he were given assistance. Mr. Wright moved and Professor Easterfield second "That Professor Sommerville be appointed Honorary Editor with two or more assistant associate editors."

Dr. Cockayne moved as an amendment "That Professor Sommerville be appointed Editor with three or more assistant associate editors." This amendment on being put to the meeting was lost. Mr. Wright's motion was then carried.

On the motion of Dr. Marsden, seconded by Professor Worley, it was resolved that Mr. W. R. B. Oliver and Dr. J. Marwick be appointed assistant associate editors.

Professor Easterfield moved that any further names be brought by the Honorary Editor before the Standing Committee which had the power of appointment. This was carried.

Reference List of Scientific Periodicals: Many members spoke of the value of the Reference List and some discussion took place as to whether a supplementary list should be printed or whether the List should be revised and reprinted. Professor Worley moved and Professor Easterfield seconded "That the question of reprinting the Reference List of Scientific Periodicals prepared by Mr. Archey be considered by the Standing Committee with power to act with the suggestion that the Department of Scientific and Industrial Research be approached and asked for its co-operation and financial assistance in the matter." On being put to the meeting this motion was lost.

Report of Honorary Librarian.

The conditions of library accommodation continue to grow more congested, and there seems to be little prospect of immediate relief. It is a great convenience to many of the regular readers to have the library of the Institute housed at Victoria University College, but it seems inevitable that this arrangement cannot endure unless the College itself is extended. The Chairman of the Victoria College Library Committee, who is also your Honorary Librarian, reports that the College library itself is in urgent need of extended accommodation. It is most desirable that the present relations of co-operation should continue as long as possible, and it is hoped that more library accommodation at the College may be created.

During the year there have been a few new exchanges. Further sets have been got ready for binding.

The Index of Scientific Periodicals in New Zealand Libraries, which was prepared by Mr. Archey, has proved of great use in assisting readers.

to find the periodicals which they require, and has helped to extend the use of the library. It is already, however, in need of considerable revision and extension.

(Signed) D. M. Y. Sommerville,
Honorary Librarian.

Honorary Librarian's Report: This report was adopted.

Fourth Pacific Science Congress.

Dr. J. S. Maclaurin's Report.

I have been requested to report briefly on the Fourth Pacific Science Congress, which I attended as a representative of the New Zealand Government and of the Institute.

Owing to no accommodation being available on the Dutch steamer sailing from Sydney to Java on April 20th, I had to take passage on a steamer leaving Fremantle on May 3rd and consequently was too late to attend the opening meeting of the Congress, which was held at Batavia on the 16th May. I was, however, in time for the remaining meetings which were held in Bandoeng. These meetings were largely attended, and, so far as I could judge, were very successful. The number of delegates and guests from abroad was said to exceed 250, and the number of papers presented was about 270.

All papers were in English, but the Council was asked to allow French as an alternative language in future congresses. It was, however, decided to adhere to the important principle, adopted at the second Congress, that only one language should be allowed.

The meetings continued till the 24th May. A final Council Meeting was held on the afternoon of that day and a final general meeting on the morning of Saturday, the 25th, at which a short address was given by the President and a number of votes of thanks were proposed by members of the Council, including one to Her Majesty the Queen of the Netherlands, proposed by your representative.

At the final Council Meeting it was decided *inter alia* that the Fifth Pacific Science Congress should be held at Vancouver.

With regard to the social side of the Congress, the arrangements for the entertainment of visitors were excellent, the Dutch treated their guests most hospitably and numerous excursions of scientific interest were well carried out. Of those which I attended the most interesting was one to the hot springs in the Pasehkawa-Kamojang district, followed next day by one to the observation station on Papandajan mountain. At the former I saw steam under high pressure issuing from iron pipes which tapped some of the steam "blowers," and was informed that the pipes had been in position for about two years and were not appreciably corroded. At present there is sufficient cheap water-power to meet the requirements of the district, but as these requirements increase it is expected that the steam pressure now going to waste will be converted into power.

The observation station at Papandajan is about 1000 feet above the floor of the crater, where numerous boiling pools and steam "blowers" indicate considerable thermal action. At the station two seismographs are installed, one for measuring the horizontal and the other the vertical component of earthquake shocks and daily readings are taken of the temperature of one of the hottest steam vents in the floor of the crater by means of a thermocouple fixed at a depth of about six feet. The temperature on the day of our visit was said to be about 500°C.! It is, therefore, not surprising that the observation station has been placed 1000 feet above this potential volcano.

(Signed) J. S. Maclaurin.

Fourth Pacific Science Congress.

Dr. Marshall's Report.

Having been appointed delegate of the New Zealand Institute, I left Wellington on April 5th, and arrived in Sydney April 9th, leaving again

on April 13th in the Dutch steamer "Nieuw Zeeland," in company with eleven delegates to the Congress from Australia. We were treated with great courtesy by the Commander and officers throughout the voyage and were enabled to understand many points of the features and geography of the islands that we passed which, under ordinary circumstances, would have been overlooked. The steamer called at Brisbane but passed through Torres Strait without stopping at Thursday Island. We steamed close to the eastern coast of Timor and various small islands before reaching Celebes, where we called at Macassar. After spending a day there we sailed for Java and reached Surabaya on April 25th. We afterwards stopped at Samarang and Cheribon before reaching Batavia on May 1st. Rooms had already been engaged for us at the Hotel des Indes, where we found some delegates from America. On May 4th the excursions to Krakatoa in the Straits of Sunda, took place. The Government of the Netherlands Indies placed two steamers at the disposal of the Congress. The various points of interest in connection with the greatest volcanic explosion of late years were visited. Members of various technical departments of the Government of the Netherlands Indies gave lectures on special features of the Krakatoa eruption as affecting different aspects of scientific research. We arrived back at Batavia early on May 6th and later on the same day visited the coral reefs in the Bay of Batavia in company with those Government specialists who had studied them.

On May 7th the Governor-General gave an official reception to the delegates in the new buildings of the Law schools. On the evening of May 8th the Governor-General gave a social reception to the delegates and dignitaries of the Netherlands Indies at the Palace. On May 9th the members of the Congress visited the Botanical Gardens at Buitenzorg and afterwards journeyed to Bandoeng. Bandoeng is situated in central Java at an elevation of 1500 feet. It is a modern town where several of the Government departments have their headquarters, as the climate is more suited to Europeans than that of any of the sea coast towns.

The sessions of the Congress were held at Bandoeng in the Technical High School from May 12-18. The formal sessions were held in the morning from 8.30 to 12.30. Committee meetings were held in the afternoons, and there were also local excursions and festivities in the evenings. The available accommodation in the hotels of Bandoeng was rather over-taxed and delegates whose names were sent in late were quartered at some distance from the town.

There were more than 200 delegates, the contingents from Japan and from China being the largest. There were two delegates from Great Britain, two from Canada, and one from South America. French Indo China, the Federated Malay States, and the Philippines were well represented. There were many delegates from the United States of America and, as before stated, there were eleven from Australia.

The Geological section was well attended throughout, as many as 100 delegates attending the discussion on coral reefs. The subjects that came up for discussion were mainly those associated with volcanic action. Distribution of coal and oil was the subject of another series of papers. There was a number of papers on coastal movements of elevation and depression in countries bordering the Pacific Ocean. I was allotted the rather unenviable task of making a digest of all those relating to the Southern Pacific and of presenting it to the Congress. Since this involved the condensation of closely reasoned papers already reduced to their minimum by their distinguished authors, the task was by no means easy.

The discussions in the Geological section proved rather disappointing on the whole. Though English was the only language admitted in the discussions, many of the delegates experienced difficulty in fully appreciating the points that were raised by the authors and also in expressing themselves adequately in the language used. While this difficulty will remain in the formal sessions, though it will probably become less pronounced in time, it does not obtrude itself in the same measure in the informal discussions outside the actual meetings.

One was enabled to meet many investigators of distinction and to gain impressions of their personal experiences and of the manner in which they approach problems of research which will be of extreme value. Information was gained that could never have been derived from mere reading. Such meetings greatly stimulate research and give an opportunity of obtaining points of view that would otherwise be entirely missed.

At Bandoeng the delegates were given opportunities of visiting the high-power wireless station, observatory, and tea estates and the crater of Papandajang.

At the final meeting at Bandoeng it was decided that the next meeting of the Congress should be held in Vancouver, and it was understood that the succeeding one would be held in French Indo China.

From Bandoeng excursions of the various sections diverged in different directions, but all sections met again three days later at Jakjakarta, where the great Buddhist Temple of Boroboedoer, 1200 years old, and various other Hindoo temples were visited. The Sultan of Jakjakarta entertained the members of the Congress at a performance of Javan dances in the large open reception room of his palace.

Seven days were given to further excursions. Arrangements had been made for the members of each section to visit localities where objects of special interest in the particular science they studied were to be found. The Geological section, for instance, was able to visit and make a special study of the effects of the activity of many of the volcanoes, which, in recent times, have caused great disasters in several of the populous districts. These proved of great interest and offered explanations of many volcanic phenomena in New Zealand which had not previously been understood. In particular the great Keloet volcano and the striking caldera of the Tengger mountain were visited. On June 4th the members of the Congress assembled at Sourabaya, where the President entertained them at a dinner.

I should like, in conclusion, to make special reference to the generous and thoughtful hospitality and courtesy which were extended to us by all sections of the community throughout our visit. His Excellency the Governor-General entertained us and emphasised the importance that he attached to the meeting of the Congress in Java. The members of Government departments were solicitous in their attentions, and we had unique opportunities of studying the interesting scientific features of Java.

To the members of the various scientific institutions of Java special thanks are due for the painstaking care they showed in explaining to us the various objects of interest.

(Signed) P. MARSHALL.

Fourth Pacific Science Congress: On the motion of Dr. Marsden, seconded by Mr. G. V. Hudson, the reports of the delegates were received.

The meeting adjourned at 12.45 p.m. for lunch.

Science Congress, 1931: Professor Easterfield explained the reasons why Nelson Institute could not undertake to organise the Science Congress for 1931, chief of these being the lack of accommodation in Nelson during the summer months.

On the motion of the Hon. G. M. Thomson, seconded by Professor Park, it was resolved that the matter be left in the hands of the Standing Committee to enquire into the possibility of its being held in Napier and with power to act.

Annual Meeting, 1931: On the motion of Mr. Eliott, seconded by Mr. Hudson, it was resolved "That unless the Act be amended in sufficient time to allow of the alteration in date the Annual Meeting be held on the last Thursday in January.

NATIONAL RESEARCH COUNCIL.

REPORT OF SUB-COMMITTEE (DR. C. C. FARR & MR. A. M. WRIGHT).

With reference to the reports received on the proposed National Research Council from the different Institutes, we, your sub-committee, would now comment as follows:—

We have perused the replies received from the various affiliated societies, and we are pleased to notice that in every Institute, with the exception of Otago, the formation of a National Research Council has been generally approved.

We are prepared to accept the scheme outlined by the Auckland Institute, omitting all reference to the proposed Section No. 11.

We also recommend that for each of the ten sections no section should have a greater number of members than 10.

We, therefore, submit this scheme for discussion at the meeting of the Board of Governors in January next.

(Signed) A. M. WRIGHT
C. COLERIDGE FARR.

The scheme referred to above is as follows:—

1. In order to include on the body all who could profitably serve, the number of members should be much increased, a limit being fixed at, say, 75 or 100 without, however, the necessity of actually reaching that limit. A limit should similarly be fixed for each section with a similar proviso. The limit need not be the same for different sections, but no section should have a limit greater than, say, 10. In some sections, *e.g.*, Anthropology and Ethnology, it may not be possible to obtain more than two or three members.

2. Each section should be constituted a sub-committee of the main body and should appoint one of its members convener and secretary.

3. Problems requiring consideration may concern one, two or more sub-committees. Each sub-committee should consider, in general by correspondence, any problem within its sphere before joint consideration by the various sub-committees concerned.

4. When a meeting of a sub-committee or a conjoint meeting of two or more sub-committees is required, the total number of representatives attending such meeting should be limited to say six. In the case of two sections three from each, and of three sections, two from each, etc.

5. Meetings of the whole body should rarely, if ever, be required. There should, however, be an executive body consisting of one member of each sub-committee, preferably the convener or his nominee, which could meet to consider matters of general policy.

6. Sections: In addition to the 10 sections named in the report, it is desirable to have a section (11) representing manufacturing industries. The sections would then be:—

(1) Agriculture and Veterinary Science
(2) Anthropology and Ethnology
(3) Astronomy, Mathematics, Seismology and Meteorology.
(4) Botany, Forestry and Zoology
(5) Chemistry and Metallurgy
(6) Economics and Statistics
(7) Engineering and Mining
(8) Geography and Geology
(9) Mental Science and Education
(10) Medical Science, Physiology and Pathology
(11) Manufacturing Industries.

7. Election of members: In sections 1 to 6 and 8 and 9 the representatives could in the first instance be elected by the professors and independent lecturers of the respective subjects in the University of New Zealand, together with Fellows of the New Zealand Institute who owe their Fellowship to the work in the section in which they vote. No elector should vote in more than one section.

In sections 7 and 10 the first election could be as suggested in the report, viz., by N.Z. Society of Engineers and the N.Z. Branch of the British Medical Association.

In section 11 suggested the representatives could be elected by sections 1, 4, 5 and 7 conjointly.

National Research Council: On the motion of Professor Worley, seconded by Mr. Oliver, it was resolved "That the Board of Governors of the New Zealand Institute approves the formation of a Research Council of the New Zealand Institute capable of functioning as a National Research Council."

On the motion of Dr. Marsden, seconded by the Hon. G .M. Thomson, it was resolved "That the proposed National Research Council be constituted round a nucleus of the Fellows of the New Zealand Institute, modification of whose constitution to be considered if necessary, and that the proposed council be intended as a non-Government body ready at all times to consider or inaugurate scientific proposals of national interest or concern or to co-operate with the Council of Scientific and Industrial Research established under the Act of 1926."

On the motion of Professor Worley, seconded by Mr. Wright, it was resolved "That the proposed Research Council be constituted on the lines of the scheme submitted by the Auckland Institute."

T. K. Sidey Summer Time Fund: Sir Thomas Sidey had expressed a wish to be present at the meeting when the proposed regulations were to be discussed and he attended at 3 p.m. Dr. Farr in welcoming Sir Thomas Sidey expressed the appreciation of the Board at his presence and at his action in entrusting the Institute with the administration of the T. K. Sidey Fund. He suggested that in view of the recent honour which had been bestowed on the Hon. Mr. Sidey, the title of the fund might be altered to the Sir Thomas Sidey Summer Time Fund.

Sir Thomas in thanking Dr. Farr stated he was not sure that the Summer Time Appreciation Committee would approve of the suggestion, but that he himself had no objection. He suggested that the committee be consulted in the matter.

Dr. Farr then read the draft of the proposed Deed of Trust.

On the motion of the Hon. G. M. Thomson, seconded by Mr. Eliott, this was adopted.

The Rules and Regulations were then read and discussed and adopted as follows:—

No. 1. The fund placed in the hands of the Board of Governors of the New Zealand Institute by the Summer Time Appreciation Committee shall be called the "T. K. Sidey Summer Time Fund." Such fund shall consist of the money originally subscribed and any further moneys which may be subsequently donated.

No. 2. The fund shall be vested in the Institute. The Board of Governors shall have the control of the said moneys and shall invest the same in any securities proper for trust moneys.

No. 3. The object of the fund shall be the encouragement of Scientific Research on the subject of light and solar radiations generally, in their relation to human welfare.

No. 4. A bronze medal donated by the Hon. Sir Thomas Sidey and a monetary prize of not less than £100 shall be awarded from time to time by the Board of Governors of the New Zealand Institute for the best contribution on the subject as aforesaid.

No. 5. The Board of Governors may specify a particular branch of the subject on which the award is to be made.

No. 6. [Some discussion arose regarding this proposed regulation and finally on the motion of Dr. Marsden, seconded by Professor Segar, it was resolved that the matter be referred to a committee with power to act. On the motion of Dr. Marsden, seconded by Professor Worley, it was resolved that the committee should be the Hon. G. M. Thomson, Dr. Farr, Professor Easterfield, Dr. Marsden (convener) and Dr. J. Malcolm.]

No. 7. The first award may be made at the Annual Meeting of the Board in 1931.

No. 8. Whenever possible the medal shall be presented in some public manner.

Sir Thomas Sidey stated that he would like the first award to be made in 1931, and he would be willing to make up the amount necessary for the prize, and also that in order that the fund might not be depleted he wished to donate the medal which he understood would cost about £100. Applause.

Fellowship N.Z. Institute: In his presidential address Dr Farr referred to the need for reform in the existing mode of selection of Fellows, On the motion of Dr. Marsden, seconded by Professor Worley, it was resolved "That a committee consisting of the President, Hon. G. M. Thomson, Dr. Marsden and Mr. Oliver (convener) be appointed to report to the annual meeting on the method of election of Fellows of the New Zealand Institute."

Amendments to Act: On the motion of Professor Park, seconded by Professor Worley, it was resolved that the necessary action in connection with the amendments to the Act be taken by the Standing Committee.

Change of Title of N.Z. Institute: On the motion of Mr. Aston, seconded by the Hon. G. M. Thomson, it was resolved "That the Standing Committee take steps to ascertain what procedure would be necessary to incorporate the word "Royal" as part of the title of this Institute."

Survey Ship "Carnegie": On the motion of Dr. Marsden, seconded by Professor Easterfield, it was resolved " That this Institute place on record its appreciation of the work done for science and navigation by the Survey Ship ' Carnegie,' and expresses its deepest regret at the loss of the vessel and extends its condolence and sympathy to the wife and family of its distinguished commander, Capt Ault, who was killed when the vessel was lost."

Scenery Preservation: On the motion of Professor Worley, seconded by Dr. Marsden, it was resolved "That a committee consisting of Dr. Cockayne (convener), Mr. Aston, Mr. Oliver and Mr. Hudson be set up to deal with the matter of scenery preservation."

A.A.A.S. Delegates: The matter of electing delegates to attend the meeting of the Australasian Association for the Advancement of Science to be held in Brisbane in May, was left to the Standing Committee.

National Parks: On the motion of Dr. Cockayne, seconded by the Hon. G. M. Thomson, it was resolved: "That the Department of Lands and Survey be requested to allow this Institute to elect a member to the Arthur's Pass Park Board and to the Mount Egmont Park Board."

Finance: On the motion of Mr. Eliott, seconded by Mr. Aston, it was resolved "That a finance committee be appointed who shall decide each year on the amount that is to be spent on printing the Transactions and other publications." The committee to be Mr. Eliott (convener), Mr. Aston, Dr. Cockayne, Dr. Marsden and the President *ex officio.*

Observatories' Committee: Dr. Farr read the report of the Institute's representatives on this committee. It was resolved to reappoint the committee, Dr. Farr, Professors Burbidge and Sommerville and Mr. A. C. Gifford.

Election of Officers: President, Dr. C. Coleridge Farr, relected; Hon Secretary, Mr. B. C. Aston, re-elected; Hon. Treasurer, Mr. M. A. Eliott, re-elected; Hon. Librarian, Professor D. M. Y. Sommerville, re-elected; Hon. Editor, Professor D. M. Y. Sommerville with Dr. J. Marwick and Mr. W. R. B. Oliver assistant associate editors; Hon. Returning Officer, Professor H. W. Segar; Managers Trust Accounts, Messrs. B. C. Aston and M. A. Eliott; Representative Great Barrier Reef Committee, Mr. W. R. B. Oliver; Representative Institute of Horticulture, Mr. B. C. Aston.

Election of Committees: Research Committee, Dr. Farr, Mr. A. M. Wright, Professor Speight, Dr. Denham and Dr. Hilgendorf, re-elected.

Hector Award Committee: Mr. B. C. Aston (convener), Professors Easterfield and Robertson.

Library Committee: Professors Sommerville, Kirk and Cotton, re-elected.

Finance Committee: Mr. Eliott (convener), Mr. Aston, Dr. Cockayne, Dr. Marsden and President (*ex officio*).

Travelling Expenses: It was resolved that travelling expenses be paid.

Votes of Thanks: Votes of thanks were passed to the Assistant Secretary, Miss Wood, and to Victoria College Council and Professor Kirk for the use of his room for the meeting. Also to the Press.

PRESIDENTIAL ADDRESS

Delivered at the Annual Meeting at Wellington on 30th January, 1930.

By Dr. C. Coleridge Farr, D.Sc., F.R.S., F.N.Z.Inst.

Gentlemen,—

Before addressing you on the subjects which will come before your notice to-day, I will ask you to stand whilst I refer to those prominent men of Science who have passed away during the year.

We greatly regret that this year, as indeed last year too, one of those who used to sit amongst us here has been called to his rest. Dr. Chilton's name and work and personality are too well known to you to need any panegyric from me. An account of his scientific work, written by the Hon. G. M. Thomson, will appear in our *Transactions*.

Captain Bollons, too, has died during the past year. He was perhaps the greatest of our authorities on matters relating to the Sub-Antarctic Islands of New Zealand, and for many years was in command of the Government steamers that paid periodical visits to those islands. Some others of us here besides myself will recall a trip in the "Hinemoa" which was organised by the Canterbury Institute many years ago to these Islands, and will realise how much of the success of that expedition was due to Captain Bollons. Dr. Cockayne has, I know, taken several such journeys with him. His genial personality, sense of humour, and immense fund of information relating to the Islands, made such a voyage an unforgettable event in the lives of those who were fortunate enough to make it.

In addition to these I think I ought to refer to the great loss sustained by Science generally, and most keenly felt in New Zealand by the deaths of Sir Baldwin Spencer, F.R.S., Dr. Geoffrey Duffield, and Captain Ault. Of these the name and work of Sir Baldwin Spencer are so well known that I need not further refer to them. He passed away full of years and of honour in the active prosecution of Ethnological investigations in South America. Dr. Duffield's name, though familiar to some of us, was not perhaps so well known. He was a South Australian by birth and came of a family very well known there almost since the foundation of the Colony of South Australia. Educated at St. Peter's College and the University of Adelaide, he went to Manchester, where he studied precise spectroscopy under Sir Arthur Schuster. From there he was appointed to the chair of Physics at Reading University College, and, as Secretary to a British Association Committee formed for the purpose, he was largely instrumental in the establishment of a Solar Physics Observatory at Canberra, in Australia, and was its first and, so far, its only Director. A man of considerable private means, he probably spent more than all his salary for the good of the new Observatory, in which he was in heart and soul most truly immersed, and his untimely death after only about a fortnight's illness removes the driving force from that institution just at a time when it was getting into its stride and beginning to issue important publications. It is greatly to be hoped

that the Federal Government will not make his death an excuse for a less vigorous policy, but will appoint some able and energetic successor as Director to carry on the work which he began so well.

The loss of the non-magnetic yacht "Carnegie," involving as it did the death of Captain Ault, is a shock from which peaceful Science will not soon recover. The actual financial loss involved in the destruction of the ship and instruments amounted possibly to between eighty and one hundred thousand pounds. Whilst the funds of the Carnegie Institution, great as they are, may not permit of the replacement of these it may perhaps be hoped that some priavte person, knowing the great work for humanity and for the increase of knowledge that that ship was performing, will come forward with an offer to build another and, let us hope, even a better ship than she was, and thus make stepping stones of their dead selves to greater things. This may be so, and let us trust it will be so, for the ship was unique in her construction and the work she did was international.

But the far greater loss of Captain Ault cannot be replaced by human hands. His loss is irreparable. A most capable mathematician, physicist, and sailor, he combined with these a lovable and genial nature, that made him an ideal leader and commander.

New Zealand Act Amendment:—

As ordered by the Board of Governors at the last annual meeting, the Standing Committee approached the Government during the year with regard to certain amendments in the Act which were desired by the Board. The time, however, has not been very opportune. Some of the amendments were of a financial character and — seeing that financial conditions are what they are — it is not surprising perhaps that these did not meet with immediate approval on the part of the authorities, but I think it was more financial stringency than any real objection to the Institute's proposals that was the cause of our failure. At any rate, in my opinion, we should approach the authorities this year and again bring before their notice our most just requests. It cannot be too strongly emphasised that the New Zealand Institute, amongst its other functions, acts as the medium of publication of most of the scientific papers which originate in the Dominion. The study and work preceding the publication of any paper is nearly always a labour of love out of which the author receives no financial reward. More often than not he is put to some personal expense in the matter and on some occasions to considerable expense. The greatest care is exercised, and all papers submitted through the proper channels—the local Institutes — are here, as with other Scientific Societies, submitted to "referees" before acceptance for publication, and it is hoped and believed that in this way few unworthy or erroneous papers find their way into the *Transactions*. Of late years the local Institutes, which are themselves performing public duties in the different centres by the building up of libraries, the supporting of museums, etc., etc., are being crippled in their work by the levy which the New Zealand Institute is compelled to make upon their funds in order to pay a debt incurred for printing the *Transactions*

during the period when we were compelled to get our printing done at the Government Printing Office though we could have had it done at a much cheaper rate elsewhere, and do now get it done, and moreover, with a promptitude and dispatch which editor after editor endeavoured to bring about at the Government Printing Office without success. We should, therefore, in my opinion, not for a moment hesitate to bring our most just claims for a remission of the remainder of this debt again before the notice of the Government. This, however, is not of the nature of an amendment of our Act, though it was brought up at the same time as the amendments which were considered necessary at the time of the last Board meeting.

I consider we should approach the Government again on these matters, and while I am dealing with this question I would like to suggest another alteration which in my view is really very much overdue. Associated with our official name, " the New Zealand Institute," there are 60 annual volumes of *Transactions*, which is indeed a noble record of work done and of services performed. But while this is so it is very probable that when the man in the street hears mention of the New Zealand Institute it brings to his mind something very different from what we really are. If he be a land agent he will think immediately of the New Zealand Institute of Real Estate Agents or whatever the exact title of that body may be. If he be a surveyor he will think of the New Zealand Institute of Surveyors; if he belongs to the optical trade he will think of the New Zealand Institute of Opticians, for indeed it is a fact that the professional society of nearly every profession has called itself the New Zealand Institute of that profession, and it is naturally known to its members as THE New Zealand Institute, a name which really by act of Parliament belongs to ourselves. It is not the very slightest use protesting that we are the people and that wisdom will die with us. It is the most natural thing in the world to happen and certainly will happen whether we like it or not. Now a very slight addition to our name would alter all this. I would suggest that we should apply for permission to prefix to our name the title " Royal " and call ourselves the Royal New Zealand Institute. Such a prefix is sanctified by long usage to Scientific Societies all over the British Empire, and it is moreover, I think, a very general and widespread wish amongst us to fashion the lines of the New Zealand Institute on those of its great and most famous prototype, the Royal Society of London. I do not think if an application were made on our behalf and through the proper channels for such permission that with the record we have behind us it would be refused, and it would draw us out from all the multitude of other New Zealand Institutes that exist, give to us a greater measure of dignity and be in the direction which the usage of years has indicated as appropriate. I would therefore commend this suggestion to your notice as one which with the minimum of change produces the maximum of effect.

Another amendment should be the provision for a Vice-President who should be resident in Wellington. We could then, perhaps, dispense with the office of Honorary Secretary.

Fellowship of the New Zealand Institute:—

It is here that I very much regret having lightly to touch a note of discord which exists amongst us. I feel, however, that I should not be doing my duty if I remained silent on it as it is, I take it, part of everyone's work to try and eradicate the young brambles which he may see growing up before they become overgrowths—like our blackberry bushes—widespread and too vigorous for easy removal to be possible. There is, however, I am sorry to say, an already strong and rapidly growing feeling, particularly amongst physicists, mathematicians and chemists, that none such, or only very favoured individuals in those branches of learning, need stand for a Fellowship with any hope of success. Not by one nor by two, but by many such, has a suggestion to stand for election been turned down, sometimes almost with scorn, and the reason for this is not far to seek. It is natural—unless special care is taken to avoid it—that in a young country like our own, with vast opportunities for the prosecution of the Natural Sciences, there should be a preponderance of those who cultivate the Natural rather than the Physical Sciences amongst its Original and Early Fellows. As the years have gone on this want of balance has, owing to the method of election, increased. Those who cultivate Natural Science are acquainted with their co-workers and with those who work in related branches, and under our mode of election they quite properly vote for them. They do not know—perhaps they have never even heard of—some of those working quite unostentatiously in mathematics, physics, or chemistry. It is, I feel sure, our mode of election which is at fault. A Selection Committee, whose duty it would be to consider the claims of candidates with due regard to scientific balance, is a much better method, and is indeed that adopted in reality by the Royal Society, though nominally all the Fellows have a vote—which, however, they never use. There I will let the matter be, feeling that a word to the wise is sufficient, and that a little calm consideration now will prevent the Fellowship becoming a fiasco, and cause it to increase in value and esteem as the years and centuries roll on.

National Research Council:—

The question of whether or not to establish a National Research Council will, I trust, be advanced a stage further at this, our Annual Meeting. It will be remembered that the question has been under discussion for some years, and became more insistent in consequence of Sir Frank Heath's recommendations. It had his strong support in a general way, but difficulties arose as to its constitution and how it could be called into being. It will also be remembered that the matter was in 1928 referred to Mr. Wright and myself to enquire into the constitution and work of similar organisations in other countries and to formulate some scheme if our enquiries pointed in the direction of the desirability for a National Research Council. After making as many enquiries as we could, Mr. Wright and myself put forward a constitution on the basis of twenty-five or so members, and our proposals came before the last Annual Meeting when they were referred to the Local Institutes for their consideration. Replies have been received from all the Institutes, and though there are still perhaps

good many different views as to the constitution of the Council one fact, and a very important one, seems to have emerged. With one single exception (that of the Otago Institute) all the replies are favourable to the establishment of a National Research Council on some basis, though it may perhaps not be in the exact way that Mr. Wright and myself suggested. That, however, is at the moment a very minor matter. If a more workable scheme can be propounded I am sure Mr. Wright and myself will be amongst the very first to accept it.* From the Institute's point of view I take it two things are necessary: (1) That the National Research Council should not supersede the Institute in its legitimate functions as defined by its Act, and (2) that the National Research Council should be so constituted that it could pronounce the best and most authoritative opinion to be obtained in the Dominion on any scientific matter which might come before it. If such were its functions and if its organisation were such as would enable the second of these to be promptly and effectively obtained I am convinced that the National Research Council would meet with no official opposition, and would be a distinct assistance and complement to the Council of the Department of Scientific and Industrial Research. It would be welcomed by Official Science as a brother, but only to help in matters of doubt and difficulty, and there to lend a powerful supporting hand.

The Preservation of the Indigenous Wild Life of New Zealand:—

All over the world action is being taken to preserve the wild life indigenous to each country. Examples are Canada, United States, Central Africa, Central Europe, Scandinavia, the Argentine and Great Britain. National parks and other reserves are set apart and the wild life is carefully protected. In New Zealand there are sanctuaries for birds such as those at Kapiti, Resolution Island and Little Barrier Island. There are national parks such as those of Egmont and Tongariro, Arthur's Pass, Mount Peel and Sounds; there are hundreds of scenic reserves and there are various reserves for different purposes: forest, education, military, water-supply, etc. These areas are, except those on islands—and many of these are not immune—threatened by the incursion of aggressive introduced forms of life. Where the original plant-covering is destroyed or where there is bare ground, introduced plants gain an entrance and alter the natural vegetation features it is desired to preserve, but the pressing danger is from introduced animals—deer, goats, including chamois, pigs, hares, rabbits, stoats, weasels, cats and rats. It has been proved that vigorous action can destroy such a menace. The goats at Kapiti Island which threatened the young forest growth on Kapiti, have now been exterminated, as have also a certain number of cats which preyed on the birds. This policy needs to be extended to all other public reserves. A start might be made with the national parks, the boards of which should have the duty of making every effort to exterminate those animals which are in any way becoming a menace to the indigenous vegetation or the fauna. A conference of all those interested

*It is with profound regret that I have to record the fact that on the y following the meeting of the Board of Governors, at which Mr. Wright present, he suddenly passed away.

has been called for March, and it is to be hoped that the policy of this New Zealand Institute, with regard to the preservation of the Tongariro National Park (see *Trans. N.Z. Inst.*, vol. 58, page 5, 1927), will be vigorously upheld by the delegates representing the Institute, and extended to other national reserves.

The Sidey Medal:—

Just in the closing hours of the Congress following on the last Annual Meeting, a telegram was received from Mr. T. K. Sidey suggesting that the Institute should become the custodian of the funds raised by shilling subscriptions as an appreciation of his efforts in favour of putting the clocks forward so as to bring the centre of the working day more nearly to noon, rather than as heretofore with three hours before and five hours after noon. The sum raised amounts to approximately five hundred pounds, and Mr. Sidey's suggestion was that a medal should be struck and awarded with a money prize for work showing the influence of light, visible and invisible, upon human welfare, health and happiness. A very hurried meeting was summoned of those members of the Board of Governors who were still in Auckland, and it was unanimously felt that the Institute should accept such a trust. During the year the capital sum has been handed over to the Institute, and Mr. Sidey's wishes in the matter have been further ascertained at a meeting of a committee set up for the purpose with him. These views and wishes have been embodied in a draft deed of trust and in regulations drawn up as a result of the conference, and will be submitted for your consideration to-day. I would only like to add that Mr. Sidey repeatedly emphasises the fact that he desired that the Institute should have large discretionary powers. Mr. Sidey's wishes were, very shortly stated, that the medal should only be awarded at intervals but that provision should be made for the continual increase of the capital sum. In the course of years, therefore, the money value of the accompanying prize will become greater and greater.

The Institute thus has within its power of award three notable medals for the encouragement of Scientific Research, viz., the Hector, the Hutton and the Sidey medals, and this battery of honourable recognitions is probably enough for our present need, and if it is desired to perpetuate the names of others it is a matter for consideration whether some other memorial than the establishment of a medal should not now be found. The value of a medal is not its intrinsic worth but it lies in the fact that it is only given for meritorious work, and it is therefore a recognition that he to whom it is awarded has striven and accomplished. We are most grateful for bequests, and our aims and objects should appeal to those who desire to leave legacies for the benefit of the welfare of mankind and the advancement of learning. Amongst our most prominent legacies is the Carter bequest, a fund which we jealously guard and which in due course—many of us realise that it will hardly be in our own period of activity—will confer great benefit upon those who follow us. The New Zealand Institute is an organisation whose life is not limited by the ordinary span of human existence but it is one called into being for the express purpose of the advancement of learning. Such moneys as are plac[ed] in our administration are assured of being legally and conscienti[ously]

used in accordance with the wishes of the testator, and I myself believe that those contemplating devoting funds for these objects will do the utmost good if they give the Institute the largest discretionary powers. Their names will, of course, be always and permanently associated with any bequests that they may make towards the objects for which the New Zealand Institute was established and for which it will always stand.

The Future of the Institute.

I look forward and I try to picture that Dominion in the days that are to be, and I see Science and scientific method playing an ever-increasing role in shaping the destinies of men and in providing for their material welfare and comfort and for their mental and spiritual happiness, and I realise that we here and now are laying foundations upon which great superstructures are bound to be erected. It behoves us to act wisely and with regard to the future as well as to the present. Our first 63 years of existence as an Institute are nearly completed but the time will come when my successor of that day will be addressing that body which has evolved out of the Board of Governors as it nears the completion of its five-hundredth anniversary. That time will come though it may seem now a long way ahead. We shall be dead and gone, but there is every reason to believe that this Institute will survive, for during the Institute's existence the world has entered the era of Science. Fifty years ago there was very little of it, and it played only an insignificant part in the affairs of mankind. To-day a method has been suggested by Sir Thomas Holland, and I think it seems a workable method, by which a knowledge of Science can be used to bring about a continuous era of peace. In those long years of prosperous usefulness which are before it what will be the position of the New Zealand Institute or of the Royal New Zealand Institute, as I trust its name will then be? It depends on how we build the few stones in the building which it is our duty and privilege to place in their position on the foundations which those early master builders, notably Sir James Hector, laid so solidly. We should have high ideals and work with energy, realising that though the Institute's life may be long our own time is, as it were, but the tick of a clock. My own view of the matter is that the New Zealand Institute should stand as does the Royal Society in England, at the head of the other more specialised scientific organisations. These are being formed at present and will continue to come into existence, and the New Zealand Institute should welcome them rather than look askance at their creation. They are not and should not be competitors with but supporters of this, the parent Scientific Society in New Zealand. Local branches of both the Institutes of Physics and of Chemistry are certain to be formed as time goes on, and local Astronomical Societies and Entomological Societies will also find their spheres of usefulness. These and others like them should be the feeders of the New Zealand Institute, and not the drainers of its means of subsistence. Let us therefore begin our deliberations to-day feeling that we are here to lay another stone in what I hope will be noble edifice, and let us therefore see to it that the stone is well truly laid.

TRANSACTIONS.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE.

Invalid Molluscan Names.

No. 1.

By H. J. Finlay, D.Sc.

[Issued separately, 29th May, 1930.]

As in my last paper of this kind (*Trans. N.Z. Inst.*, vol. 57, pp. 488-533, 1927), the name at the left hand side of each note forms the subject of discussion, while that opposite it on the right (if any) is the necessary substitute here proposed or determined. The first reference given under the name discussed is to the place of its proposal.

Cucullaea ponderosa Hutton, 1873.

Hutton's proposition of this name (*Cat. Tert. Moll.*, p. 27) will invalidate that of Whiteaves (Mesozoic fossils, vol. 1, pt. 4; *Geol. Surv. Canada*, p. 286; 1900); the Canadian fossil may be renamed *Cucullaea whiteavesi* nom. nov.

Limopsis compressus Dall, 1895:— **Limopsis solicola** nom. nov.
(*Proc. U.S. Nat. Mus.*, vol. 18, No. 1034, p. 16).

This was described from 1793 fathoms, Gulf of Panama (Cat. No. 122889), but G. & H. Neville had appropriated the specific name in 1874 (*Journ. Asiat. Soc. Bengal*, n. s., vol. 43, pt. 2, p. 28). In October, 1908 (*Bull. Mus. Comp. Zool.*, vol. 43, No. 6, p. 394; Pl. 7, Figs. 7, 8), Dall figured and re-discussed the species, which he said was "not unlike *L. bassi* Smith from New Zealand." *L. bassi* is not a New Zealand shell, but a synonym of the Australian *L. tenisoni;* the American shell may be renamed as above.

Pecten delicatula Hutton, 1873.
(*Cat. Tert. Moll.*, p. 30).

The invalidation through Hutton's name of *delicatulus* Philippi, 1887 (*Tert. quart. Verst. Chiles*, p. 209) will not matter, as Wilckens (*Rev. Fauna Quir.-Schichten*, p. 224; 1904) has noted that it is only a young *Pecten granulatus* d'Orb., 1846.

Lima crassa Hutton, 1873.
(*Cat. Tert. Moll.*, p. 33).

This was described from the Lower Gorge of the Waipara, a[illegible] as no specimens are known, and the type is lost, the name is [illegible]ery

unsatisfactory. Fortunately it is preoccupied by Forbes, 1844 (*13th Rep. Brit. Assoc.*, p. 193), so that Hutton's name may be altogether dismissed.

Crassatella corrugata Tate, 1886:— **Salaputium aldingensis** nom. nov.

(*Trans. Roy. Soc. S.A.*, vol. 8, p. 147).

Not of Adams and Reeve, 1850 (*Zool. " Samarang,"* pt. 7, Moll., p. 82). The Australian Tertiary species was described from Aldinga, and compared with *astartiformis* (= *communis* Harris), but with heavier and fewer sulcations. It evidently belongs to the group of tiny Crassatellas to which Iredale has given the name *Salaputium.*

Lucina minima Ten.-Woods, 1876.

In " Critical Remarks on Some South Australian Mollusca " (*Trans. Roy. Soc. S.A.*, vol. 21, p. 48; 1897), Tate remarked that " *Lucina minima* Ten.-Woods (*Proc. Roy. Soc. Tas.* for 1875, p. 162; 1876) antedates *L. tatei* Angas by two years." But Tenison-Woods' specific name is invalid, having been used previously by Roemer, 1836 (*Verst. Norddeutsch. Oolith.*, vol. 2, p. 118) and also by Brown, 1841 (*Trans. Manchester Geol. Soc.*, vol. 1, p. 66). May, however, keeps *tatei* as a distinct species from *minima* (*Check-List Moll. Tas.*, p. 18; 1921), but queries *L. perobliqua* Tate, 1892 (*Trans. Roy. Soc. S.A.*, vol. 15, p. 128) as a synonym of the latter. The investigation of this may be left to those more directly concerned.

Tellina donaciformis Deshayes, 1855.

This name appears in Hedley's Queensland List (p. 349), but is preoccupied by Nyst, 1835 (*Coq. Foss. Anvers,* p. 5). I do not know if there are synonyms.

Corbis elegans Deshayes, 1843.

(In Cuvier, *Regne Anim.*, disciples ed., Moll., descrip. to Pl. 102).

This also appears in the same list (p. 347), but in the same year as Deshayes, Buvignier also proposed a *Corbis elegans* (*Mem. Soc. Philom. Verdun,* vol. 2, p. 228); which has priority I do not know.

Genus **Finlaya** Marwick, 1927:— Genus **Marwickia** nom. nov.

Though I appreciate Dr. Marwick's compliment to me in this name (*Trans. N.Z. Inst.*, vol. 57, p. 596), I am unfortunately prevented from accepting it as there is an earlier *Finlaya* Theobald, 1903 (*A Monograph* of the *Culicidae* or Mosquitoes, vol. 3, p. 281), proposed for a Penang mosquito. There could be no more fitting renomination than the proposal of *Marwickia* nom. nov. to replace *Finlaya* Marwick, and it gives me much pleasure to make this substitution. It is only right that the Veneridae of New Zealand, so ably monographed by Dr. Marwick, should include for one of the earliest and most interesting forms a generic term based on his own name. There is but one species, *Marwickia parthiana* (Marwick), the Paleocene.

Dosinula elegans (Hutton, 1873) (*Callista*).
(*Cat. Tert. Moll.*, p. 21).

Marwick (*Trans. N.Z. Inst.*, vol. 57, p. 609; 1927) has noted that "It is doubtful if this species is distinct from *D. zelandica.* The type is the only specimen known, and it is in a damaged condition." Under these circumstances it seems best to regard the name as preoccupied by *Callistus elegans* Boheman, 1848 (*Ins. Caffr.*, vol. 1, pt. 1, p. 127). This is the more welcome as there are numerous prior associations of the term *elegans* with other related Venerid genera, such as *Venus* (Wood, 1828; Adams & Reeve, 1850), *Cytherea* (Lamarck, 1805; Koch, 1844), *Artemis* (Conrad, 1843), and *Tivela* (Verrill, 1870). If further specimens from Kanieri prove to be a distinct form, a new name may then be imposed.

It may be noted that Koch's preoccupied name *Cytherea elegans* is included without comment in Hedley's *Prelim. Index Moll. West Australia,* p. 15, 1916, as *Gafrarium elegans* (Phil.).

Lutraria elongata Gray, 1837:— **Lutraria porrecta** nom. nov.
(*Ann. Mag. Nat. Hist.*, n. s., vol. 1, p. 374).

Recorded from Queensland by Hedley (*Marine Fauna of Queensland,* p. 351; 1909), but the name is preoccupied by Muenster, 1835 (*N. Jahrb. f. Min.*, p. 435), and also by M'Coy, 1844 (in Griffith, *Syn. Carb. List. foss. Ireland,* p. 52).

Patella aculeata Reeve, 1855.

This common Australian shell is included in Hedley's "*Index Moll. W. Australia,* p. 36, 1916, and recorded from Victoria by Pritchard and Gatliff (*Proc. Roy. Soc. Vict.*, vol. 15, n. s., pt. 2, p. 193; Feb., 1903), but the name had long ago been used by Gmelin (*Linn. Syst. Nat.*, ed. 13, pt. 1, p. 3751; 1791). Iredale (*Proc. Linn. Soc. N.S.W.*, vol. 49, pt. 3, pp. 238-241; *Oct.* 24, 1924) discusses this and other species, but does not mention the preoccupation. Pritchard and Gatliff give *Patella squamifera* Reeve, 1855 as a synonym, and this name has been preferred by Hedley (*Check-List Mar. Fauna N.S.W.*, p. M 50; 1917).

Fissurella elongata Philippi, 1845:— **Diodora philippiana** nom. nov.

This species (described in *Abb. Conch.*, vol. 2, pt. 2, p. 33; *Arch. f. Naturg.*, vol. 11, pt. 1, p. 144) and *Fissuridea corbicula* (Sow., 1862) are included in Hedley's "Marine Fauna of Queensland," p. 352, 1909. Philippi's shell may be renamed as above as there is a *Fissurella elongata* M'Coy, 1844 (in Griffith, *Syn. Carb. List foss. Ireland,* p. 43), originally proposed as a *nomen nudum* in 1842. Sowerby's combination had also been forestalled, but only as a *nomen nudum,* by Andrezejovski, 1832 (*Bull. Soc. Imp. Nat. Moscou,* vol. 4, p. 564).

Calliostoma hedleyi Dautzenberg, 1925:—
Calliostoma dautzenbergi nom. nov.
(*Bull. Inst. océan Monaco,* No. 457, p. 8).

Pritchard and Gatliff had already appropriated this name (*Proc. Roy. Soc. Vict.*, vol. 14, pt. 1, p. 182; Aug., 1901) for a Victorian shell.

Calliostoma iheringi Dall, 1927:— **Calliostoma amazonica** nom. nov. (*Proc. U.S. Nat. Mus.*, vol. 70, art. 19, p. 5).

This name was previously used by Ortmann (*Amer. Journ. of Science,* vol. 5, No. 10, p. 373; 1900) for a South Patagonian fossil. Dall's Recent species may therefore take the new name *Calliostoma amazonica;* Dall notes that "this is the largest and most conspicuous species of the genus from the Brazilian coast."

Delphinula crenata Kiener, 1839:— **Liotina infensa** nom. nov.

This prominently serrate species was described from the Philippines (*Spec. Coquilles,* Delphinula, No. 11) and has been recorded as *Liotia crenata* from Queensland by Hedley. As the combination *Delphinula crenata* had been anticipated by G. B. Sowerby II (*Gen. Shells,* p. 39; 1833), I propose to rename Kiener's shell as above.

Genus **Brookesena** Finlay.

I proposed this in *Trans. N.Z. Inst.,* vol. 57, p. 390; Dec. 23, 1926. There is a Brachiopod genus *Brooksina* Kirk, 1922 (*Proc. U.S. Nat. Mus.,* vol. 60, p. 1), but as the spelling and derivation are different, both names may be allowed.

Were my name a homonym, Powell's name *Vindex* would have to be considered. This was inadvertently proposed in *Trans. N.Z. Inst.,* vol. 57, p. 539; Feb. 1, 1927, where Powell remarks, "For *Mathilda neozelanica* Suter and *Alics* (sic) *succincta* Suter, Iredale and Finlay have proposed a new genus *Vindex,* citing the former species as type." This was the name given to the group in the MS. of the "Further Commentary," which Powell saw before publication; it was subsequently changed to *Brookesena,* since *Vindex* was found to be preoccupied by Kaup, 1871 (*B.E.Z.,* 15, heft 4, p. 78) for a beetle.

Crepidula convexa Yokoyama, 1925:—
Crepidula yokoyamai nom. nov.
(*Journ. Coll. Sci. Tokyo Imp. Univ.,* vol. 45, art. 7, p. 13).

This may be renamed as above, as Say had previously used Yokoyama's name (*J. Acad. Nat. Sci. Philad.,* vol. 2, p. 227; July, 1822).

Sulcerato n. gen. Type: *Erato* (*Eratopsis*) *illota* Tate.

This is a Kalimnan shell from the upper Muddy Creek beds. When describing it (*Trans. Roy. Soc. S.A.,* vol. 13, pt. 2, p. 217; Dec., 1890, and vol. 15, pt. 1, Pl. 13, F. 11; July, 1892) Tate remarked, "In *Eratopsis* it comes nearest in shape to *E. nana,* but it is broader, shorter, and not granulated." The difference in shape and the absence of heavy ridges and granulations give the Australian shell so different an appearance from *Eratopsis barrandei* Hoernes and Auinger, the genotype (from the Viennese Helvetian), that a distinct name is necessary. *Eratopsis* H. & A., 1880 (*Gast. der I and II mar. Stufe,* pt. 64) is preoccupied by *Eratopsis* of an anonymous

writer, R. L., 1817 (*Allg. Lit. Zeitung.*, vol. 1, p. 288) for a butterfly. Cossmann (*Ess. Pal. Comp.*, vol. 5, p. 183; Dec., 1903) gives *Eratotrivia* Sacco, 1894, based on the Eocene *E. crenata* Desh. as a synonym; this has the same *Trivia*-like sculpture, and should be used for the European species included in *Eratopsis.*

Genus **Powellia** Finlay:— Genus **Badenia** nom. nov.

I proposed this (*Trans. N.Z. Inst.*, vol. 57, p. 403; Dec. 23, 1926), with *P. lactea* Finlay as type, for a group of small shells which were temporarily located in the Family Rissoidae. The generic name I find was previously used by Maskell for a Coccid (*Trans. N.Z. Inst.*, vol. 11, p. 223; 1879), genotype: *P. vitreo-radiata* Maskell, the subsequent reference of which (*idem.*, vol. 22, p. 164; May, 1890) to *Triozoa,* in the Psyllidae, does not validate my later use of the name. Consequently I propose *Badenia* as a suitable substitute for the molluscan genus. I also remove it from the Rissoidae, believing that the Family Melanellidae is a better location. The species of *Badenia* closely resemble shells which Dall (*Bull. Mus. Comp. Zool.*, vol. 18, pp. 324 and 325; Pl. 18, Figs. 7, 8, 12; June, 1889) has placed in *Aclis;* they do not resemble true *Aclis,* but are apparently more happily placed near *Melanella* and *Eulima* than near *Dardanula* or any Rissoid genus.

Aclis has been dismissed from Neozelanic literature, but apparently should be reinstated, though not for the species Suter included there. Judging by what figures and descriptions are available to me, I cannot see any generic distinction between *Aclis supranitida* Wood, the genotype, and the Petane and Castlecliff *Turritella* (*Eglisia*) *planostoma* Hutton, 1885 (*Trans. N.Z. Inst.*, vol. 17, p. 320; Pl. 18, F. 19). Perhaps actual specimens would be unlike, but I cannot separate the New Zealand species at present. The *Graphis* group also seems to be represented by undescribed Recent species in New Zealand.

Fasciolaria fusiformis Val.

This rather rare Australian species was noted to be distinct from *coronata* by Verco (*Trans. Roy. Soc. S.A.*, for 1895, p. 106), was lumped with that species by Prichard and Gatliff (*Proc. Roy. Soc. Vict.*, vol. 10, p. 272; 1897), and was again maintained as distinct by May (*Check-List Moll. Tas.*, p. 78; 1921). In Sherborn's *Index Animalium,* section 2, pt. 11, p. 2610, 1926) the only entry of this combination is credited to Philippi, 1847 (*Palaeontographica,* vol. 1, pt. 2, p. 70). Valenciennes's species is not recorded, and I cannot find its date. The matter must be left to those who can investigate the necessary literature.

Fusus exilis Menke, 1843:— **Fusinus dampieri** nom. nov.

(*Moll. N. Holl.*, p. 26).

When I discussed *Fasciolaria exilis* Tate (*Trans. N.Z. Inst.*, 57, p. 505; 1927), I noted the clash of *Fusus exilis* Menke

Australian species, recorded by Hedley in his *Prelim. Index Moll. W.A.* (p. 58, 1916), and *Fusus exilis* Conrad, a North American Tertiary species. I have now found that Conrad's name dates from 1832 (*Foss. Shells Tert. N. Amer.*, vol. 1, p. 17), while there is also a *Fusus exilis* Philippi, 1841 (*Tertiarverst. Wilhelmshohe,* p. 25), so that the Recent species needs renaming as above.

Buccinum inflatum Hutton, 1873:— **Aeneator huttoni** nom. nov.

1873. *Buccinum inflatum* Hutton, *Cat. Tert. Moll.*, p. 6.
1887. *Cominella inflata* Hutton, *Proc. Linn. Soc. N.S.W.* (2), vol. 1, p. 209.
1914. *Cominella inflata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 3.
Not *Cominella inflata* (Hutton): Suter, *l.c.*, p. 25; Pl. 2, Figs. 6a, b.
1924. *Verconella inflata* (Hutton): Finlay, *Proc. Mal. Soc.*, vol. 16, pt. 2, p. 103.
1926. *Verconella inflata* (Hutton): Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 412.

I propose this name to replace *Buccinum inflatum* Hutton, 1873, non *Buccinum inflatum* Shaw, 1811 (*Nat. Misc.*, p. 22; Pl. 959), *nec* Lamarck, 1822 (*Anim. s. Vert.*, vol. 7, p. 270).

The species is not well known, and has been generally neglected. The following re-description is based on examination of the unique type specimen, which was thought to be lost, but which has been found by Dr. Marwick amongst the Geological Survey collections.

Apex conoidal, of 2½ smooth whorls. Adult whorls five, first three slightly convex, body whorl relatively very large and globose, contracted at base. First three whorls with about 14 low transverse ribs, becoming obsolete on fourth whorl; fine regular spiral cords over whole surface, 10-12 on spire whorls, interstices slightly wider and sometimes with a weak thread. Spire acute, subequal to aperture without canal. Aperture ovate, angled above, outer lip broken, but evidently sinuous; growth lines in shape of a shallow reversed S. Canal broken off, but probably long and bent to left.

Height (incomplete), 30 mm.; width, 18.5 mm.

Locality—Kanieri River.

Holotype in N.Z. Geol. Surv. collection.

In spite of the loss of the canal it is fairly certain that this species is an *Aeneator;* there is no trace of a Cominellid notch, and the spout was almost certainly long.

The shell which Suter described and figured (see synonymy) as "*Cominella inflata* (Hutt.)" is really *Acominia errata* (Finlay, ?4) (= *Buccinum carinatum* Hutton, 1873; preoccupied). Dr. ...ick informs me that there was no MS. drawing by Buchanan ...*flatum,* so that Suter apparently guessed at the species on the ...he specific name.

Neptunaea costatus Hutton, 1877:—

Nassicola contracta Finlay.

1877. *Neptunaea (Sipho) costatus* Hutton, *Trans. N.Z. Inst.*, vol. 9, p. 594; Pl. 16, F. 2.
1887. *Siphonalia costata* Hutton, *Proc. Linn. Soc. N.S.W.* (2), vol. 1, p. 209.
1915. *Siphonalia costata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 22.
1924. *Aethocola costata* (Hutton): Finlay, *Trans. N.Z. Inst.*, vol. 55, pp. 501 and 502.
1926. *Austrofusus (Nassicola) costatus* (Hutton): Finlay, *idem.*, vol. 56, pp. 233, 236; Pl. 56, F. 12 (Target Gully shell).
1926. *Austrofusus (Nassicola) contractus* Finlay: *idem*, p. 236; Pl. 56, F. 10, 11 (Clifden, band 7).

I propose to rename this well-known Awamoan shell as above, since the basis of Hutton's name is preoccupied by *Neptunea costata* Link, 1807 (*Beschr. Nat. Samml. Univ. Rostock*, vol. 4, p. 13).

Re-examination of additional material convinces me that the differences between the Awamoan *costatus* and my *Austrofusus (Nassicola) contractus* are too slight to deserve specific recognition. Target Gully shells on the whole are more vertically compressed, but identical examples occur; the small differences seem due to facies rather than time.

Besides the three species *contracta, nassa,* and *magnifica,* which I described in *Trans. N.Z. Inst.*, vol. 56, pp. 235, 236; 1926, I now suggest that *Siphonalia compacta* Suter, 1917 (*N.Z. Geol. Surv. Pal. Bull. No. 5*, p. 29; Pl. 4, F. 11), from Broken River, Trelissick Basin, should be referred to this genus.

On the other hand, I would now refer *magnificus* on account of its size, spiny habit and other details of sculpture, and position of fasciole to *Austrofusus* s. str., though of an aberrant type, found so far only at Clifden.

Atkinsonella n. gen.

I provide this for the Table Cape (Janjukian of Tasmania) *Buccinum fragile* Ten.-Woods, 1877 (*Proc. Roy. Soc. Tas.* for 1876, p. 107; Feb. 27, 1877), at the same time pointing out that the specific name is very likely preoccupied. There is a *Buccinum belcheri* Rve. var. *fragile* Verkruzen, 1878 (?) (*J. B. mal. Ges.*, vol. 5, p. 352), treated as a full species by Sars, 1878 (*Moll. arct. Norweg.*, p. 260)—which will need a new name—and probably others have used this combination.

May (*Proc. Roy. Soc. Tas.* for 1918, p. 115; April 1, 1919) h[illegible] referred this species to *Loxotaphrus* and synonymised *Tropho[illegible] wyni* Pritchard. The latter species was described (*Proc. Ro[illegible] Vict.*, vol. 8, n. s., p. 79; Pl. 2, F. 7; April, 1896) from Sp[illegible] three examples from Table Cape being included by the [illegible] Pritchard's figure and description seem to indicate th[illegible]

Creek shells are relatively wider and more strongly costate than the Table Cape ones, and as he was always a "lumper" it is probable that both names should be employed. I have seen no Spring Creek examples, and can only recommend re-investigation of this synonymy.

Loxotaphrus was provided by Harris (*Cat. Tert. Moll. B.M.*, pt. 1, p. 165; March 25, 1897) for *Phos* (?) *variciferus* Tate, 1888, from the Muddy Creek Balcombian. This can hardly be regarded as congeneric with *fragilis*. *Loxotaphrus* has a totally different contracted aperture, with a prominent raised flange for the inner lip; it is stoutly built and has a narrow recurved canal and an embryo of 1½ smooth turns, the intial whorl oblique and immersed. *Atkinsonella* has a wide simple aperture (not unlike *Austrofusus*) and inner lip, a fragile shell, an open unrecurved canal, and a protoconch of 2½ whorls, the initial portion very flattened and tightly coiled. They may be related, but can hardly be merged; both genera can be placed in the Neptuniidae in the meantime.

Cossmann (*Ess. Pal. Comp.*, vol. 4, p. 109; Oct., 1901) placed *fragilis* in *Siphonalia* s. str., which has only Family relationship.

Buccinum veneris Filhol, 1880:— **Eucominia filholi** nom. nov.

This Campbell Island regional form, described in *Compt. Rend.*, vol. 91, p. 1094) I propose to rename as above, as there is a prior *Buccinum veneris* Basterot, 1825 (*Mem. geol. envir. Bordeaux*, p. 47; Pl. 2, F. 15) from the Miocene of Europe.

Purpura depressa Martin, 1880:— **Thais demissa** nom. nov.

(*Die Tertiars. auf Java*, p. 43).

Not of Link, 1807 (*Baschr. Nat. Samml. Univ. Rostock*, vol. 4, p. 14).

Columbella coniformis Martin, 1884:— **Columbella conella** nom. nov.

(*Samml. Geol. Reichs-Mus. Leiden*, ser. 1, bd. 3, p. 117).

Not of G. B. Sowerby, 1844 (*Proc. Zool. Soc. Lond.*, vol. 12, pt. 133, p. 49).

Voluta conoidea Tate, 1889:— **Volutoconus ralphi** nom. nov.

This and *V. limbata* Tate were described (*Trans. Roy. Soc. S.A.*, vol. 11, p. 125; April, 1889) as the Balcombian ancestors of the Recent *Voluta coniformis* Cox, the genotype of *Volutoconus* Crosse, 1871. Cossmann (*Ess. Pal. Comp.*, vol. 3, p. 131; April, 1899) includes only these three species in the genus, and figures *conoidea*. That specific name cannot be maintained, since Renier had already used it for a *Voluta* in 1804 (*Tavole*, p. 7); there is also a *Voluta* *onoidea* Bosc, 1801, based on *Bulla conoidea* L., 1767. Accordingly pply the name *Volutoconus ralphi* nom. nov. for Tate's *conoidea*. notype itself is not on too firm a footing, for there is a *Voluta* *is* Wood, 1828 (*Suppl. Index Test.*, F. 31) but this may be *uricula coniformis* Ferussac, 1821, and that in turn on *formis* Bruguiere, 1789.

Voluta lirata Johnston, 1880.

Described in *Proc. Roy. Soc. Tas.* for 1879, p. 37; July 21, 1880. In *Trans. N.Z. Inst.*, vol. 57, p. 514, 1927, I included this Tasmanian Janjukian species in my new genus *Notopeplum.* I have since found that there are two previous proposers of the combination *Voluta lyrata;* Brocchi, 1814 (*Conch. Subap.*, p. 311), and G. B. Sow., 1, 1825 (*Cat. Shells Tankerville*, p. 80). As this gives an opportunity of fixing a definite type specimen, I am not renaming Johnston's shell, but am describing the species as new from my own Table Cape material. At the same place I nominated *victoriensis* Cossmann (= *polita* Tate; preoccupied) as genotype of *Notopeplum,* taking Pritchard's opinion (*Proc. Roy. Soc. Vict.*, vol. 8, p. 96; 1896) that this covered all the Victorian species referred to *maccoyi.* I had then seen only Balcombe Bay material, but the subsequent reception of some Muddy Creek shells makes it plain that Pritchard was in error. Tate was perfectly correct (*Trans. Roy. Soc. S.A.*, vol. 11, p. 127; 1889) in separating a Muddy Creek species as *polita* from the other Balcombian ones he took as *maccoyi.* This is the species which must bear the name *victoriensis* Cossmann, and be regarded as genotype of *Notopeplum* Finlay, though it was not the species I had in mind when I proposed the name (see *balcombensis* later); fortunately it makes no difference to the conception of the genus. Tate's figure of it is good, and it differs from the usual Balcombe Bay specimens exactly as Tate stated. Tate figured a Muddy Creek specimen (*l.c.;* Pl. 2, F. 2) as *maccoyi,* but all these Balcombian forms disagree with the Table Cape series, so I also describe as new the common Balcombe Bay form. I do this in preference to supplying a name for Tate's figure, as it is not certain where that specimen is, and because the Balcombe Bay shells differ a little from the Muddy Creek ones. I think there are several new species of this group in the Australian Balcombian and Janjukian, and Pritchard's method of lumping them all as *maccoyi* does not appeal to me.

Notopeplum saginatum n. sp.

Shell of moderate size, inflated. Embryo of 2-2½ whorls, dome-shaped, rather symmetrically wound, tip small, probably Scaphelloid, developing a low keel and shoulder ornamented with small axial riblets towards its close, merging imperceptibly into adult shell, the first whorl of which is much encroached on from below by the next whorl. Adult whorls 5, flat, with a faint trace of a medial concavity, very slightly bulging at lower suture; this bulge is pronounced on body whorl, which is considerably more inflated than in the other species of this group; rapidly contracted in a faint concave curve to canal. Rather prominent, extremely fine and dense spiral grooving over whole surface, which is moderately polished and shining. Numerous thin and sinuous axial riblets on all but last whorl, where they a[illegible] degenerating into irregular growth ridges; about 27 on antepe[illegible] mate whorl of type, about 22 in paratype, 4-6 times their ow[illegible] apart, ribs in the form of a very shallow reversed S, equally d[illegible] from suture to suture, no nodules on swellings. Outer li[illegible]

erately thick inside. Pillar stout, with four mitriform subequal and subequidistant plaits. Canal very shallow and widely open, no notch, fasciole merely a faint swelling.

Height, 51 mm.; of spire, 20.5 mm.; width, 22.5 mm.

Locality—Table Cape, Tasmania (Janjukian).

Type and one paratype in Finlay collection.

A wider, more ornamented shell than *maccoyi* from the same beds.

Notopeplum balcombensis n. sp.

Very close to the Muddy Creek species figured by Tate as *maccoyi*. Same smooth highly polished and thin shell, four ridge-like lamellar pillar plaits, the lower two more oblique, same embryo (as already described by me in *Trans. N.Z. Inst.,* vol. 57, p. 514, 1927), except that the protoconch of Muddy Creek shells is markedly smaller and higher. Differs chiefly in lower and wider spire and stouter shell, the spire angle being about 45 degrees instead of about 35 degrees. The embryo is not so large as in *victoriensis,* and is slightly flattened on top instead of being bluntly pointed; the spire is also not so low, and the whorls not so convex (the sutures therefore less cut in), though the shell is approximately as broad, the whorl inflation being less sudden and lower down than in *victoriensis.*

Height, 41 mm.; of spire, 14.5 mm.; width, 12 mm.

Locality—Balcombe Bay, marly clays (Balcombian).

Type and four paratypes in Finlay collection.

Pleurotoma plicatella Hutton, 1886.

This was described (*Trans. N.Z. Inst.,* vol. 18, p. 333) from Wanganui (Pliocene), and subsequently referred by Suter to *Drillia* (*Crassispira*) (*N.Z. Geol. Surv. Pal. Bull. No. 3,* p. 35; 1915). There is a *Raphitoma plicatella* Bellardi, 1847 (*ex* Jan MS.) (*Mem. R. Accad. Sci. Torino,* 2, vol. 9, p. 620), but whether Jan published a *Pleurotoma plicatella* in 1832 I do not know. However, it does not much matter, for I cannot separate Castlecliff specimens from the Recent *Pleurotoma novae-zelandiae* Reeve, the genotype of my *Phenatoma.*

Pleurotoma nodilirata Murdoch and Suter:—

Bathytoma murdochi nom. nov.

T. W. Kirk first described this shell from the Petane Pliocene (*Trans. N.Z. Inst.,* vol. 14, p. 409; 1882) as *Pleurotoma tuberculata;* this name being preoccupied by Gray, Murdoch and Suter (*idem.,* vol. 38, p. 284; 1906) substituted *Pleurotoma* (*Hemipleurotoma*) *nodili-ta* as the species name. In the use of this combination they were stalled by E. A. Smith, 1878 (*Ann. Mag. Nat. Hist.,* dec. 4, vol. 94) who described a *Pleurotoma* (*Drillia*) *nodilirata* from the e Islands. The New Zealand shell is therefore renamed as

Pleurotoma (Gemmula) fusiformis Thiele:—

Gemmula thielei nom. nov.

Pleurotoma (*Gemmula*) *fusiformis* Thiele, 1925 (*Wiss. Erg. D. Tiefsee Exped.*, vol. 17, p. 214), being preoccupied about half-a-dozen times—originally by J. de C. Sowerby, 1823 (*Min. Conch.*, vol. 4, p. 119)—may be changed to *Gemmula thielei* nom nov.

Pleurotoma laevis Hutton, 1873:— **Splendrillia aoteana** nom. nov. (*Cat. Mar. Moll.*, p. 12).

Preoccupied by Bellardi, 1848 (*Mem. R. Acc. Sci. Torino* [2], 9, 542). The type is from Stewart Island and is in the Dominion Museum, Wellington.

Terebra martini Vredenburg, 1925:—

Terebra vredenburgi nom. nov.

When Vredenburg (*Mem. Geol. Surv. India*, vol. 50, pt. 1, p. 24, footnote; 1925) noticed the preoccupation of the name *Terebra bicincta* Martin, 1879 (*Die Tertiars auf Java*, p. 33), he proposed the new name *T. martini*, as I have already noted (*Trans. N.Z. Inst.*, vol. 57, p. 519; 1927). But this combination had already been used by Tesch in November, 1915 for a Timor fossil (*Pal. Timor*, vol. 5, pt. 9, p. 38), so that the Javan species must be renamed a second time. I also propose to replace the Timor *Terebra martini* Tesch by *Terebra teschi* nom. nov. on account of the still earlier *Terebra martini* English, 1914 (Univ. Cal. Pub., *Bull. Dept. Geol.*, vol. 8, No. 8, p. 216; Nov. 7, 1914), a Californian Tertiary species.

Terebra sulcata Marshall, 1919:—

Zeacuminia tahuia n. gen. et nom. nov.

This name is proposed to replace *Terebra sulcata* Marshall (*Trans. N.Z. Inst.*, vol. 51, p. 232; Pl. 16, F. 2), not *Terebra swainsoni* var. *sulcata* Pease, 1868 (*Am. Journ. Conch.*, vol. 5, p. 67). Marshall's species is from Hampden (Tahuian), and is the first New Zealand member of a long line of species, including *suteri* Marwick, *transitorsa* Marwick, *biplex* Hutton, *pareoraensis* Suter, and *orycta* Suter. These I have discussed and temporarily referred (*Trans. N.Z. Inst.*, vol. 57, p. 435, 1926) to *Acuminia* Dall, following Iredale's reference of the Australian *brazieri* Angas and *leptospira* Tate to this genus. But the New Zealand series has always a longer canal, and squarish body whorl, rather suddenly cut in, giving the shell a more beaked appearance, also the axial ribs are much more strongly developed, and the fasciole is bordered by a strong ridge, so that *Zeacuminia* is proposed, with *tahuia* nom. nov. as type, as a convenient group name for these species. At least one Australian Tertiary species, *T. additoides* Ten.-Woods belongs to this section, which seems to be replaced by typical *Acuminia* in the Pliocene and Recent periods in Australi *Zeacuminia* does not seem to extend above the Awamoan in New land.

At the reference cited I referred to the Recent *T. fl* Suter as an *Acuminia* and possibly a synonym of *venosa*

Neozelanic. This is totally erroneous. I have since obtained numerous specimens of this species from Cape Maria van Diemen, the type locality, and can now affirm that it is a *Pervicacia,* a distinct species, and undoubtedly Neozelanic. It does not seem to occur anywhere but in the extreme North. Together with it occurred a few specimens of a species like *tristis,* but much larger, wider, and with fewer and heavier axials; this seems so like what Suter described from Lyall Bay as var. *crassicostata* that I am induced to reinstate that name as a valid species. If the Lyall Bay type is really only a form of *tristis* then these Cape Maria shells will need a distinct name, but I leave *crassicostata* at present as ranging over the whole North Island.

Actaeon praestitus Finlay:— **Actaeon ambiguus** (Hutton, 1885).

On the ground that Hutton's *Odostomia sulcata* (*Trans. N.Z. Inst.,* vol. 17, p. 319; 1885) was an *Actaeon,* and therefore preoccupied by *Auricula sulcata* Lamarck, 1804, also an *Actaeon,* I altered the specific name as above (*Proc. Mal. Soc.,* vol. 16, pt. 2, p. 105; June, 1924). The homonymity in this case is not exact, so it is best to record that there is an *Odostomia sulcata* Garrett, 1874 (*Proc. Acad. Philad.* for 1873, p. 223) which absolutely upsets Hutton's name. My substitute, however, cannot stand; examination of type specimens shows that *Admete* (?) *ambigua* Hutton, 1885 (*Trans. N.Z. Inst.,* vol. 17, p. 320; Pl. 18, F. 18), from " Wanganui " is based on a juvenile specimen of the large *Actaeon* that occurs there, *i.e., sulcatus,* described on the previous page from the same lot of specimens. Unless, then, the name *ambigua* proves to be preoccupied in *Actaeon* or *Admete*—and I can find no previous proposition—*Actaeon ambiguus* (Hutton) must replace *praestitus* Finlay. Suter (*N.Z. Geol. Surv. Pal. Bull. No. 3,* p. 28; 1915) confirmed Hutton's reference to *Admete,* but there is no resemblance.

New Shells from New Zealand Tertiary Beds.

PART 3.

By H. J. FINLAY, D.Sc.

[*Issued separately, 29th May, 1930.*]

PLATES 1–6.

Barbatia awamoana n. sp. (Figs. 63, 64, 65).

This is the Awamoan (Miocene) representative of the Recent *novaezelandiae* Smith, and its direct ancestor. It is markedly more elongate and not so high, the anterior end is fairly regularly convex instead of rather squarely truncate, and the internal grooves are not so prominent. I am unable to observe any other differences, but as these are quite constant, it would be misleading to report *novaezelandiae* from the Awamoan.

Length, 51.5 mm.; height, 28 mm.; diameter (1 valve), 11 mm. Corresponding dimensions for a Castlecliff shell, 48 x 28 x 11 mm.

Locality—Target Gully, shell-bed (Awamoan), type and numerous other specimens; also Awamoa beach-boulders.
Type in Finlay collection.

Cosa wanganuica n. sp. (Figs. 75, 76, 77).

Very close to *trigonopsis* (Hutt.), and intermediate between that species and *filholi* (Bernard), but nearer the former. Differs at sight in having the anterior side straight, while in *trigonopsis* it is concave and excavated; this gives the latter species a more slender and sharply beaked aspect. The concentric riblets are slightly finer, and the prodissoconch somewhat larger. The radial ribs are slightly more numerous, 16-17 as against 13-14 in *trigonopsis*. Otherwise in the general shape and the narrow umbos the new species is more allied to the Nukumaruan species than to *filholi*.

Height, 3.8 mm.; breadth, 3.3 mm.; thickness (1 valve), 1.2 mm.

Locality—Castlecliff "papa" (Castlecliffian), very common in certain patches, especially where there are the remains of a tree-coral or bryozoan, but otherwise rare.

Type in Finlay collection.

This species has always been mistaken for *trigonopsis*, but the latter is apparently limited to the Nukumaruan.

Cosa trigonopsis (Hutton).

1885. *Mytilicardia trigonopsis* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 324.
1893. *Mytilicardia trigonopsis* Hutton, *Macleay Mem. Vol.*, Plioc. Moll., p. 85; Pl. 9, F. 94.
1898. *Philobrya trigonopsis* (Hutt.): Tate, *Trans. Roy. Soc. S.A.*, vol. 22, p. 87.
1915. *Philobrya trigonopsis* (Hutt.): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 50.

Suter's drawing in the Macleay Memorial Volume is quite a good representation, but the specimen was evidently worn. Nukumaru shells agree exactly with Petane ones in shape and number of ribs.

Cosa filholi (Bernard, 1897). (Figs. 78, 79, 80).

(This Recent species is discussed here for convenience).

Iredale has expressed the opinion (*Proc. Mal. Soc.*, vol. 9, p. 75, 1910), as noted by Suter (*Man. Moll.*, p. 1083), that this is the young stage of *Philobrya costata* Bernard. Suter at the same place gives corrected dimensions and affirms that there are two species. He is perfectly correct. I have sorted out the two forms described by Suter as *costata* and *filholi* from many different dredgings in the Cookian, Forsterian, and Rossian provinces. *Filholi* is rather commoner in the north, *costata* in the south; both species, but especially the latter, are very common in 60 fathoms off Otago Heads.

Suter's description of the number of ribs in each species is erroneous; it is rather difficult to count the ribs exactly, as they become so fine and weak near the dorsal margins, but there are usually about 13 in *costata* and 15 in *filholi*. The latter, however, can always be separated by the character of the ribs, which are triplicate, the centre portion being carinate and high, the side pieces thread-like and low, the whole forming a sharp triangular ridge, with a triangular projection at the margin; in *costata* the ribs are single, stout, and raised, flattish on top, with a median linear groove, forming a squarish projection at the margin. The interstices in *filholi* are wide, shallow, and flat, twice the width of the ribs or more at the margins; in *costata* they are narrow, deep, slightly concave, equal to or less than the ribs at the margins. There are also marked differences in the outline of the shells, *filholi* being constantly less vertically elongate, more squarish, more inflated, the anterior margin slightly convex instead of straight and excavated, etc. The surface of *filholi* has a curious waxy sheen, absent in *costata*. The two species are thus amply distinct.

Whether *filholi* of Suter's "*Manual*" is really *filholi* Bernard, however, is another matter. The original description and figures are not available to me, but, pending their re-examination in the light of the comparative notes given above, I think Suter's determinations may be taken as correct. If *filholi* Bernard should turn out to be really based on a juvenile *costata*, a new name will be needed for the quite distinct *filholi* auct.

Of the two species, *filholi* has the longer ancestry, as known at present. Suter (*Man. Moll.*, p. 858) says of *costata* that " The Pliocene *P. trigonopsis* Hutton (*Mytilicardia*) is very nearly allied, but the riblets are finer and more distant, and they are lacking the median groove," and again (*N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 50, 1915) of *trigonopsis* that " This species is allied to *P. costata* Bernard, but it is much larger; the prodissoconch is indistinct and convex; the costae are not grooved, but keeled, and the concentric threads are not wavy but straight." But these are the very characters that approach *trigonopsis* to *filholi*, to which, not to *costata*, it is the ancestor. It is very like *costata* in shape, being more vertically elongate than *filholi*, and not having a convex anterior side, but there is the same tendency to flatten and form sharp angles at the basal corners as in *filholi*, and the sculpture at once shows the alliance. Probably the initial error is due to Tate, who at the reference given under *trigonopsis* stated, "The above amended generic reference is based on the study of co-types kindly transmitted to me by the author of the species. It closely resembles *P. costata*, but which [*sic*] has thicker and closer ribs." He also states that he received specimens of *costata* from Bernard; it seems improbable that the author of *filholi* would confuse the two species, so we can only conclude that for once Tate's usually accurate perception was at fault.

I have seen no Tertiary representatives of *costata;* over 100 shells from Castlecliff were all *wanganuica.*

Apart from the shape, *trigonopsis* and *wanganuica* differ from *filholi* principally in having the ribs rather wider and closer (interstices little more than their own width), projecting further at margins, the keel serrated with sharp spikes instead of almost smooth, and the concentric ribs in the interstices not cords with narrower grooves between, but thread-like, with wide interstices.

I have elsewhere shown (*Trans. N.Z. Inst.*, vol. 57, p. 448, 1926) that *Hochstetteria* Velain, 1878, should replace *Philobrya* auct., not of Carpenter, 1872, for the *meleagrina*-series in New Zealand (*Philippiella* Pfeffer, 1887, being a synonym), and proposed the genus *Cosa* for the *costata* series. This should include, besides the four Neozelanic members mentioned, several undescribed Tertiary species, and the following Australian members: (Recent), *fimbriata* Tate, 1898 (*Trans. Roy. Soc. S.A.*, vol. 22, p. 87), *tatei* Hedley, 1901 (*Rec. Austr. Mus.*, vol. 4, p. 24), *pectinata* Hedley, 1902 (*Mem. Austr. Mus.*, No. 4, p. 229), and *parallelogramma* Hedley, 1906 (*Proc. Linn. Soc. N.S.W.*, vol. 29, p. 544); (Tertiary), *bernardi* Tate, 1898 (*Trans. Roy. Soc. S.A.*, vol. 22, p. 88), and *praenuntia* Tate, 1898 (*idem.*).

Notovola tainui n. sp. (Figs. 46, 56, 81).

Shell close to *novaezelandiae* (Reeve), but more inflated, especially towards the ventral margin, and more laterally expanded (less circular). Right (convex) valve with ribs same in number and arrangement, and with the same faint radial lineations and scratches on their surface; but the ribs are broader, flatter on top, with sharp edges, and the interstices are very much deeper, giving the appearance of deep channels scored across the surface instead of more or

less rounded furrows. This is especially noticeable towards anterior side. The interior shows 14-15 strong square-cut ridges separated by interstices 1½-2 times their width; in the Recent species there are 16-18 ridges with interstices 1-1½ times their width. On the left valve there are about 14 very strong and high ribs (mostly higher than broad), evenly rounded on top, with interstices 2-3 times their width; *novaezelandiae* (Fig. 82) has about 16 considerably weaker ribs (broader than high), flattened on top, with interstices 3-4 times their width. The left valve is noticeably concave, while its Recent descendant has a mostly flat valve, concave only beneath the umbos. Interstices and sides of ribs on both valves, but especially the right, are densely ornamented with fine raised lamellae, equi-distant and several times their width apart; these are not noticeable in the Recent species.

Height, 88 mm.; width, 100 mm.; thickness (1 valve), 29 mm. (type).

Height, 109 mm.; width, 115 mm.; thickness (1 valve), 29 mm. (paratype).

Locality—Castlecliff "papa" (Castlecliffian).

Type and one paratype, in Finlay collection.

"Tainui" was the name of one of the first Maori canoes to reach New Zealand. If, as seems probable, this Castlecliff shell is the first migrant of this group of *Pecten* from Australia (or the north) to our shores, the specific name is not inept.

Notovola marwicki n. sp.

This differs from all the others of this group in its subobsolete sculpture on the concave valve. Instead of prominent raised ribs with more or less deeply excavated wide interstices as in *fumatus, albus, meridionalis, novaezelandiae,* and *tainui,* this species has low, lightly convex (almost flattish) ribs, with merely narrow indentations (almost sublinear grooves) between. The ribs flatten and widen still more towards ventral margin, and the interstices become wider and less definite so that near the edge the sculpture is merely a series of undulations. In shape, convexity, and interior, the right valve is practically identical with the South Australian *albus* Tate, but the beak is markedly broader. The left valve is also practically inseparable from *albus,* but the ribs are slightly broader, and the valve definitely concave. This also separates it from *novaezelandiae,* whose ribs on this valve are also higher and rounder. The laminae so prominent in the interstices of *tainui* are absent on the right valve of *marwicki,* but present on the flat valve, where however they are at least three to four times as numerous; densely packed, their own width or less apart, imparting a curious roughened surface to the shell.

Height, 65 mm.; width, 72 mm.; thickness (1 valve), 22 mm.

Locality—Castlecliff "papa" (Castlecliffian), apparently rare.

Type in Finlay collection, one other specimen in N.Z. Geol. Survey collection.

The Sydney (Peronian) form *N. fumatus* (Reeve) approaches nearest to *marwicki* in rounding and weakening of ribs and interstices

on right valve, but it has such high and strong beaks and so convex and characteristically shaped a shell that relationship does not seem very close. The only Recent New Zealand species, *novaezelandiae* (Reeve), seems in some ways intermediate between *tainui* and *marwicki,* as if they had combined to produce it; both the Pliocene forms carry various sculptural features to excess, though in different ways.

Gari oamarutica n. sp.

Very close and directly ancestral to the Recent *lineolata* (Gray), but relatively more elongate and narrower. The greatest difference is seen in the anterior end, which is much more acuminate, the dorsal margin being straight instead of lightly convex, and much more narrowly convex on meeting the basal margin. No other differences observable.

Length, 30.5 mm.; height, 14.5 mm.

Locality—Awamoa beach-boulders (Awamoan), type and several fragmentary specimens. Also Target Gully shell-bed (numerous broken shells), Otiake, and other Awamoan and Hutchinsonian localities.

Type in Finlay collection.

Maorimactra acuminella n. sp.

Close and directly ancestral to the Recent *M. ordinaria* (Smith), but more inequilateral, the anterior side less produced, the posterior side more produced and much sharper. Shell higher, more inflated, posterior dorsal carina better marked, anterior one weaker. Pallial sinus truncated instead of squarely rounded.

Length, 15 mm.; height, 12 mm.; thickness (1 valve), 3.5 mm.

Locality—White Rock River shell-bed (Awamoan), type and several more beautifully preserved valves; also Nukumaru (Nukumaruan), and Castlecliff (Castlecliffian).

Type in Finlay collection.

This species has a range from Miocene (perhaps earlier) to topmost Pliocene, but alters in the Recent fauna. It is highly exceptional in that the Castlecliff forms agree not with the living ones but with the Awamoan ones.

Scalpomactra continua n. sp.

Very close and directly ancestral to the Pliocene and Recent *S. scalpellum* (Reeve), but differing at sight in its longer lateral teeth, especially posteriorly. It also has a better marked posterior dorsal keel, and consequently a sharper posterior end; the shell is slightly more elongate and has a deeper pallial sinus.

Length, 24 mm.; height, 14 mm.; width (1 valve), 3.5 mm.

Locality—White Rock River shell-bed (Awamoan), type and numerous specimens. Also Target Gully, Pukeuri, Awamoa, Chatton, Wakaia, etc.

Type in Finlay collection.

This will be the species Dr. Marwick has recorded from Chatton with the remark (*Trans. N.Z. Inst.,* vol. 59, p. 906, 1929), " The

Recent species *Scalpomactra scalpellum* is doubtful. More specimens are required to show whether they are to be separated as a distinct species or not."

Scalpomactra biconvexa Powell and Bartrum (*Trans. N.Z. Inst.*, vol. 60, p. 405; F. 108) from Oneroa, Waiheke Is., is still more elongate and apparently has more convex dorsal margins; the hinge is stated to be as in *scalpellum.*

The description of the last three new species removes three more records of Recent species from the Awamoan fauna. Extremely few of the "Miocene" species regarded by Suter as representing living forms are really inseparable from Recent shells when carefully compared. When the Awamoan fauna has been thoroughly revised it is to be expected that the percentage of Recent species will be very low —probably under 5 per cent.

Scutus petrafixus n. sp. (Fig. 23).

Shell ancestral to the Recent *S. breviculus* Blainv., but differing at sight in its proportions. It is considerably less elongate and relatively wider; it appears to be a trifle wider in front than behind, whereas *breviculus* narrows anteriorly. The hinder end, as far as can be seen, seems to be regularly convex instead of squarely truncate, and there is no indication in the growth lines of the notch that is well marked in *breviculus.*

Length, 50 mm.; width, 33.5 mm. Corresponding dimensions for *breviculus*—60 x 34.5 mm.

Locality—Oamaru limestone (Ototaran).

Type in Finlay collection.

The exact locality of the single specimen is unknown, but it is certainly from an Oamaru collection, and the matrix is hard, fine-grained limestone, slightly glauconitic. The specimen is possibly somewhat compressed, but does not appear much distorted. In spite of these deficiencies, the genus is so rare in the Tertiary that it is worth recording, if only to show that *breviculus* had a long Neozelanic ancestry, and is not of recent importation.

Crosseola proerrata n. sp. (Figs. 11, 12).

Ancestral to the Recent *C. errata* Finlay (*Trans. N.Z. Inst.*, vol. 57, p. 402, F. 33; 1926), from which it differs in smaller size, more depressed shell, and greater prominence of the axials. Apex of one smooth flatly bulbous whorl. As in the Recent species, there are 3 subequal spirals on spire whorls, a fourth showing just at lower suture; 8 rather low and weak spirals, twice their width apart on body whorl; 6 of these stronger. Axials about same in number as in Recent shell, but much heavier and blunter, altogether over-riding spirals instead of strongest between them. Basal fasciolar cord not nearly so strong and projecting as in *errata,* the base consequently flatter. As in that species, the aperture is perfectly circular and unnotched, with only a pad at the fasciole, thus differing from the Australian *cancellata.*

Height, 1.4 mm.; diameter, 1.4 mm.

Locality—Target Gully shell-bed (Awamoan), two examples. Also one specimen with slightly stronger basal keels from Clifden, band 6B (Hutchinsonian). From Pourakino, Riverton, I have also a single specimen which probably represents a distinct species, the shell being very depressed and the basal keels very strong; it seems to be adult, but I prefer not to give it a name till more material is available.

Type in Finlay collection.

Crosseola sultan n. sp. (Fig. 6).

Shell large for the genus, prominently 5-keeled. Apex small, globose and smooth, of one sub-helicoid whorl, the tip slightly bulbous. Four succeeding whorls, the first two with 2 spirals (1 on keel and 1 below), next with a third smaller one arising out of suture below, body whorl with 5 strong sharp much raised keels (equidistant and twice their width apart), and a stout fasciolar cord as strong as the keels but blunter. Shoulder area twice the width of interstices between keels, with no spiral sculpture, but a convex medial bulge. Radial riblets very dense fine and flexuous, interstices 1-2 times as wide; they extend from suture to fasciolar cord, practically absent on outer edge of keels, prominent in interstices; on upper and under surface of spiral keels the axials are very sharp and fine, and 2-3 extra lamellae are intercalated between them, the axial sculpture thus appearing there several times as dense. Spire lower than aperture, suture slightly canaliculate. Aperture large, circular. Outer lip with 5 sharp triangular serrations, the sudden terminations of the keels. No basal notch, but aperture slightly channelled along fasciole pad. Inner lip weakly callous and a little reflected. Umbilical chink weak.

Height, 4 mm.; diameter, 3 mm.

Locality—Target Gully shell-bed (Awamoan); one example.

Type in Finlay collection.

This fine species—apparently the largest of the genus—is also an ancestral form, being nearly related to the Recent *C. cuvieriana* (Mestayer) (*Trans. N.Z. Inst.*, vol. 51, p. 132, 1919). That species is also strongly 5-keeled, and shows the sudden dense lamination on the sides of the keels. It differs at sight, however, in the spacing of the sculpture, the axials being less numerous, and 3-4 times their width apart, and the spiral keels being unevenly distributed, a gap almost as wide as the shoulder between the upper peripheral pair, the rest close together on base.

Dolicrossea awamoana n. sp. (Fig. 10).

Shell ancestral to, and very like, the Recent *D. vesca* Finlay (*Trans. N.Z. Inst.*, vol. 57, p. 403, F. 32; 1926), but less globose, and with a strong basal notch. The spiral grooves are about twice as numerous, the outer lip more thickened, and the fasciolar cord much more projecting, carinating the base and interrupting the peristome (which is almost continuous in *vesca*) with a strong canal-like notch.

Height, 2.7 mm.; diameter, 2 mm.

Locality—Awamoa blue clays (Awamoan), one specimen. Also one damaged shell from Clifden, 6B (Hutchinsonian) which appears inseparable at present.

Type in Finlay collection.

Dolicrossea clifdenensis n. sp. (Figs. 25, 26).

Like the previous species, but spire more exsert, a more pronounced tabulation below suture, spiral lirae coarser on early whorls and obsolete on body whorl, a still stronger and more twisted fasciole cord, slightly deeper and narrower notch, and a more excavated pillar.

Height, 2.5 mm.; diameter, 1.7 mm.

Locality—Clifden, 6C (Hutchinsonian), several specimens.

Type in Finlay collection.

Argalista proumbilicata n. sp. (Figs. 20, 21, 22).

Small, depressed-turbinate, umbilicate. Spire low, whorls about 3½, including protoconch, convex, base flattened. Embryo smooth, next half whorl with three strong ridges, the median one prominently raised; these die away rather suddenly and leave the upper surface of the shell rather smooth except for a few spiral grooves, three fairly close near suture, one rather distant, then usually a smooth space down to periphery (but this may bear two or more grooves); below this there are numerous much closer spiral grooves down to umbilicus, getting wider apart as they near it, about 14 altogether up to middle line of periphery. Suture impressed and margined by a slight swelling. Aperture circular, somewhat effuse at pad; outer lip thin. Umbilicus deep, open but not wide, surrounded by a heavy coarsely crenulated margin that eventually forms the prominent pad at base of pillar.

Height, 1.7 mm.; width, 2.5 mm.

Locality—Target Gully shell-bed (Awamoan), type and numerous other examples.

Type in Finlay collection.

This species, *effusa* Marwick, and *umbilicata* Powell, are distinguished from the *fluctuata* line by the more widely open umbilicus. The present species is specially distinguished by its heavily crenulated umbilical edge and post-embryonic ridges; from *effusa* it also differs in other details of spiral sculpture and depressed shell, while the Recent *umbilicata* has a still more open umbilicus, effuse aperture, and weaker pad.

Argalista kaiparaensis n. sp.

Similar to *proumbilicata,* but much smaller, no post-embryonic sculpture of ridges; upper surface evenly and rather prominently grooved, with quite a stout cord margining suture, lower surface finely grooved; the same very coarsely crenulated margin to the umbilicus; pad sub-triangular instead of semi-circular.

Height, 1.0 mm.; width, 1.4 mm.

Locality—Pakaurangi Point, Kaipara (Hutchinsonian).

Type in Finlay collection.

This is easily the smallest species of the genus; the state of the umbilicus, pad, and aperture shows that it is fully adult.

Argalista impervia n. sp.

Shell small, turbinate, not depressed, imperforate. Spire rather raised for the genus, whorls four including protoconch, convex, base flattened, last whorl descending. Sculpture of spirals only, post-embryonic half whorl with ornament somewhat similar to *proumbilicata,* but the two outer ridges much feebler, giving the whorl merely a carinate appearance; suture very narrowly but distinctly margined, a few close grooves near suture, rest of upper surface practically smooth and shining; below periphery very dense and numerous fine spiral grooves, regular and equidistant, but fading out before reaching centre; a smooth calloused surface surrounds the umbilical depression, sometimes with a few irregular crenulations. Aperture circular, not effuse, outer lip thin and sharp, but rapidly becoming very thick inside. Columella concave, calloused, somewhat excavated or sunken at the umbilical area, umbilicus absent or limited to a pin-prick depression. Pad very tiny.

Height, 2.3 mm.; width, 2.9 mm.

Locality—Target Gully shell-bed (Awamoan), common. Not seen from any other locality.

Type in Finlay collection.

This was always taken by Suter for *fluctuata* (Hutt.); it may be ancestral to it, but differs at sight in its entirely closed umbilicus, higher and more solid shell, less expanded and more descending last whorl, and weaker sculpture on upper surface. *A. arta* Marwick, from the Chathams, is much more depressed (but either his figure or his dimensions are quite wrong—I am basing comparison on the figure) and has prominent spiral sculpture all over.

Badenia zebina n. sp.

(*Badenia* is a substitute name for *Powellia* Finlay, preoccupied —see elsewhere in this volume).

Shell minute, the smallest of the genus, short and rather squat. Embryo indistinct, of about one whorl, smooth, compact, not marked off from the shell whorls, of which there are about three. Whorls convex, bulging at lower third, smooth and shining; here and there for short distances extremely obscure indications of a few thread-like keels appear. A very blunt and low subangulation closely encircles the narrow but distinct chink-like umbilicus. Aperture as in *B. lactea* (Finlay), the type of the genus, but relatively much smaller, the walls solid, more outwardly effuse but less channelled below, more backwardly inclined above, the varix behind the edge heavy. Spire about one and a third times aperture in height.

Height, 1.9 mm.; diameter, 1.2 mm.

Locality—Otiake, sandy beds above limestone (Upper Ototaran), 14 examples.

Type in Finlay collection.

Like *lactea* in whorling, but much smaller, and with a much shorter spire. Somewhat like a minute *Zebina* in general appearance.

Rissopsis castlecliffensis n. sp.

Shell small, cylindrical, with weak axial and obscure spiral sculpture. Embryo well-developed, of nearly two whorls, beginning in a blunt and flattened point, ending in a weak varix. Three and a-half succeeding shell whorls, lightly convex, the sutures well marked, very faintly submargined below. Weak and irregular axial ribs (less or more than own width apart in different places) on spire whorls, obsolete on body whorl, these are frequently worn off altogether. Obscure indications here and there of spiral lirations. Spire 2½ times height of aperture, which is small, pressed to body whorl, subcontinuous, peristome thin and sharp, without a varix, half hiding the tiny umbilical chink, somewhat effuse below.

Height, 2.3 mm.; diameter, 1.0 mm. (type).

Height, 2.7 mm.; diameter, 1.2 mm. (worn paratype).

Locality—Castlecliff "papa" beds (Castlecliffian), 6 examples.

Type in Finlay collection.

Generically located with some doubt; I have seen no authentic examples of the genus, but the aperture and general habit are reminiscent of Australian shells placed here. If correct, it is the first record of this genus from New Zealand.

Rissopsis fricta n. sp.

Differs from the previous species only in much smaller size, slightly more convex whorls, a little more tightly clasping at suture, and more effuse aperture anteriorly.

Height, 1.8 mm.; diameter, 0.7 mm.

Locality—Target Gully shell-bed (Awamoan), 5 examples, the adults all worn.

Type in Finlay collection.

Magnatica fons n. sp. (Fig. 51).

Ancestral to *M. planispira* (Sut.). Shell smaller, and with a decidedly higher and more pointed spire, much more the shape of *M. altior* Finlay. The umbilical characters, however, show that it belongs to *Magnatica* s. str., not to section *Spelaenacca*. Umbilicus narrow, not cylindrical, with no internal groove, but a narrow thread some distance from the main funicle, which is feeble and indistinct, close to upper callus. A rather sharp ridge winds round just outside umbilicus and enters it just below parietal callus pad; this ridge is similar to the angulation in *planispira* but is sharper.

Height, 22.5 mm.; diameter, 21 mm.

Locality—Waihao Downs (Bortonian).

Type in Finlay collection.

This is the earliest *Magnatica*. The separation of the *Spelaenacca* group was also quite ancient, as shown by the occurrence of a true *Spelaenacca* (the following species) in the McCulloughs Bridge greensand.

Magnatica (Spelaenacca) parilis n. sp.

Extremely similar and certainly ancestral to *altior* Finlay. Only one somewhat crushed specimen is at present available, but this dif-

fers in more rounded spire, less spreading parietal callus, steeper posterior channel to the aperture, considerably wider and more open umbilicus, still deeper groove within umbilicus and stronger carina below it, and better developed funicle, which is well separated from parietal wall.

Height, about 33 mm.; true width uncertain.

Locality—McCulloughs Bridge greensand, just below limestone (Tahuian).

Type in Finlay collection.

The section *Spelaenacca* has a deep groove within the umbilicus, bounded by a ridge below; it is more a sudden step down than anything else, like an escarpment in geology. *Magnatica* has merely a thin distant thread-ridge, with no step down; a less pervious umbilicus, somewhat flattened from one side, and a stronger angulation bounding the umbilicus. I think my *Magnatica* (*Spelaenacca*) *altior* (*Trans. N.Z. Inst.*, vol. 56, p. 228; Pl. 60, Figs. 3, 4; 1926) should be reduced to a synonym of *Natica* (*Magnatica*) *sutherlandi* Marwick (*l.c.*, vol. 55, p. 555; Pl. 56, F. 1; 1924); my only specimen of the latter is somewhat worn, but there are no essential differences, and the horizons are the same. I overlooked comparison with this species when I described *altior*. This will leave the species of *Magnatica* as *fons* Finlay, *approximata* (Suter), *planisipra* (Suter), and *nuda* Marwick, while *Spelaenacca* contains *parilis* Finlay, *sutherlandi* (Marwick) (= *altior* Finlay), *clifdenensis* Finlay, and *rectilatera* Finlay.

Cabestana debilior n. sp. (Fig. 31).

Very close to the Recent *C. waterhousei* Ad. & Ang., but more slender, with a longer beak. Spirals have exactly the same arrangement, but the main ones (more especially above base) are weaker, and the interstitial ones stronger. Axials much weaker, merely thin ridges, many times their width apart, extending from suture to suture, instead of stout ribs much more prominent on periphery and 1½-2 times their width apart. Intersections with peripheral spirals produced into tiny rather sharp nodules instead of prominent tubercles. *Waterhousei* has four intervariceal subequidistant ribs till the penultimate whorl, on that and on body whorl there are five, the last weaker; *debilior* has four on all whorls, the first becoming very weak on last two whorls, very unequally spaced, the first near varix, the next three subequidistant, then a wide space before next varix with no axial ribs. Sutures more cut in.

Height, 53 mm.; of spire, 22.5 mm.; width, 27 mm.

Locality—Castlecliff "papa" (Castlecliffian).

Type in Finlay collection.

Iredale (*Trans. N.Z. Inst.*, vol. 47, p. 460; 1915) noted that *waterhousei* had not been observed in New Zealand, and was a distinct species from *spengleri*. Since then Powell (*l.c.*, vol. 57, p. 560; Pl. 33, F. 2; 1927) has recorded and figured a living specimen obtained by La Roche at Parengarenga. His figure does not exactly agree with a topotype I have, and in view of the presence in New Zealand of this ancestral Castlecliff species, his shell may possibly be

distinct from South Australian specimens. More specimens are needed to settle this point; it is evidently yet another of the Australian Cymatiidae which ocean currents have borne across to us—whether in Pliocene or Recent times one cannot yet say.

Iredale (*Rec. Austr. Mus.*, vol. 17, No. 4, p. 177; Pl. 41, F. 2; 1929) has recently separated the New South Wales Recent form from the typical South Australian *waterhousei* as a subspecies *frigidulum*, and this is very close indeed to *debilior*, but is apparently still more slender and has the axial sculpture relatively weaker in proportion to the spiral. Powell and Bartrum (*Trans. N.Z. Inst.*, vol. 60, p. 425; F. 87, 88; 1929) have described *Cymatium tetleyi* from Waiheke Is. as probably ancestral to *waterhousei*, but the resemblance in this case is much less close, and a different group seems to be represented.

Pleia n. gen.

A group of the Fasciolariidae, differing from *Pleuroploca* Fischer chiefly in having only one weak plait on the pillar instead of three. *Pleuroploca* has the twist of the pillar marked by a strong ridge, with two more separated by deep furrows above it; *Pleia* has no ridge at the twist, but a single not strong plait above it, the columella not excavated on either side of it. The shell habit is taller and more slender than *Pleuroploca;* there are strong coarse axial ribs and spiral cords; embryo large, paucispiral, the top flattened and blunt.

Type: *Fasciolaria decipiens* Tate, 1888.

The genotype is from the Australian Balcombian (Oligocene ?). Tate says there are "two oblique plaits hardly visible from without," but this is a mistake; even grinding away the upper whorls shows no more than a single weak plication.

Pleia otaioensis n. sp. (Fig. 30).

Shell rather narrow and slender, with crude axials and bold narrow spirals. Protoconch rather large, of two (?) whorls, the tip somewhat flattened, the next whorl a little bulbous, following 2-3 whorls worn so that junction of apex and shell cannot be seen. Nine whorls including apex; fairly regularly convex, subshouldered at upper third, the shoulder steeply sloping and straight, the shoulder angle very bluntly rounded, thence sloping inwards in a light curve to lower suture. Sutures inconspicuous, submargined by a narrow thread below. Axials 9 per whorl, thick and prominent, bluntly rounded, their summits about own width apart, but bases swelling to meet each other, and hardly separated; ribs weak on shoulder, just reaching upper suture, thickest medially, a little weaker at and undulating the lower suture, rapidly disappearing below suture on base, the lower part of which and the canal are free from axials. Five equal and strong spiral cords run over ribs and interstices between shoulder angle and lower suture, with four more weaker ones on shoulder, and numerous progressively weaker ones on base and canal below main five, which have wider interspaces (twice their own width) than others. Outer lip heavily crenulated by internal ribs arranged in pairs which meet internally in sharp angles. Parietal wall with a prominent callus tubercle forming a marked channel with

outer lip. Inner lip smooth, well limited. Columella fairly straight, twisted a little at inception of canal, with a single inconspicuous plait and a weak groove above it, a little above this twist. Canal long, open, slightly bent to left, longer than aperture (but broken off).

Height, 34 mm.; of spire, 16 mm.; of aperture, about 10 mm.; diameter, 10.5 mm.

Locality—Blue Cliffs, Otaio River, sandstone above limestone (Upper Ototaran ?).

Type in Finlay collection.

This is what Suter identified (*Alph. List N.Z. Tert. Moll.*, p. 14, 1918, and *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 62, 1921) as *Fasciolaria johnstoni*. But *Fusus johnstoni* Ten.-Woods, 1877 (*Proc. Roy. Soc. Tas.* for 1876, p. 94), figured by Tate (*Trans. Roy. Soc. S.A.*, vol. 10, p. 136; Pl. 12, F. 4a, b; 1888), and represented by authentic topotypes in my collection, is a rather thin shell with very regular spiral ornament, a sharply keeled periphery on the body whorl, a straighter canal, and an exceedingly small paucispiral embryo; it has a weak plait on the pillar, but seems not distantly related to true *Colus*, while the New Zealand shell appears to be much closer to *Fasciolaria decipiens* Tate (*l.c.*, p. 150; Pl. 8, F. 1), especially the tall-spired Muddy Creek form. The details of aperture, pillar, and embryo seem to be identical, but *otaioensis* is a smaller shell, more regularly ornamented. As these shells are quite unlike the Recent tropical *Murex trapezium* L., the genotype of *Pleuroploca* Fischer, a new group *Pleia* has been made for them. I have thought it better in this case to make an Australian shell the type, as *decipiens* is common, while *otaioensis* is known to me from but a single specimen, though probably further members of the group will turn up in New Zealand. Possibly *Fasciolaria concinna* Tate also belongs to this group, but *tenisoni* T.-W., *cryptoploca* Tate, *cristata* Tate, and *rugata* Tate are all much closer to *Pleuroploca*. Iredale (*Proc. Linn. Soc. N.S.W.*, vol. 49, pt. 3, p. 265; Oct. 24, 1924) has located the Recent Sydney forms in *Pleuroploca*, but remarks that "All the Australian radulae agree in showing fewer cusps on the laterals than the typical *Fasciolaria* or *Pleuroploca*," and that "there is a fossil *Fasciolaria decipiens*, a form not unlike *bakeri*, showing the plications very obscurely." I have not seen *bakeri* Gat. & Gab., but as it is generally treated as a subspecies of *australasia* Perry, it is probably nearer to *Pleuroploca* than to *Pleia*.

Proximitra apicalis (Hutton). (Figs. 68, 72, 73).

1873. *Mitra apicalis* Hutton, *Cat. Tert. Moll.*, p. 7.
1915. *Vexillum apicale* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull, No. 3*, p. 20; Pl. 1, F. 5.
1926. *Proximitra apicalis* (Hutton): Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 410.

Dr. Marwick informs me (*in litt.*) that "Buchanan's drawing, published by Suter, gives a very good idea of the appearance of this shell. The latter's statement that there are 25 nodules on the shoulder angle was based on two specimens from Awamoa mentioned as plesiotypes. They, however, differ much in shape from Hutton's holotype

(which has now been found), and represent an undescribed species." (Described later as *Parvimitra pukeuriensis*).

The type was from Awamoa, and my collection contains one topotype, one doubtful specimen from Rifle Butts, and eight shells from Pukeuri. The species is specially characterised by its high spire. There are 14-15 nodules per whorl, the body whorl rather small and slender, the spire angle about 35 degrees, the spirals with linear interstices, one or two stronger on periphery, and the keel median. Figures are here presented of an Awamoan topotype (Fig. 68), a normal Pukeuri shell (Fig. 73—body whorl broken away), and a senile Pukeuri specimen (Fig. 72).

Dimensions of a normal Pukeuri shell, 7.8 x 4.5; of the senile figured shell, 15 x 5.3 mm.

Proximitra tumens n. sp. (Figs. 67, 69, 70, 71).

This occurs together with *apicale,* and may possibly be an extreme form of it, but the specimens are easily separated; *tumens* is the more common. It differs in its inflated shell and shorter spire (lower than aperture instead of subequal or higher), the angle of which is notably wider, about 45 degrees. The spirals seem exactly the same, but the shoulder nodules are more numerous, 17-21 per whorl, rather smaller and weaker than in *apicalis.*

Height, 17 mm.; width, 6.5 mm.

Locality—Pukeuri, sandy beds in the Road Cutting (Awamoan), type and 10 others; also Rifle Butts, Awamoa, All Day Bay blue clays, and Pareora shelly limestone (all Awamoan horizons).

Type in Finlay collection.

The Awamoa specimen here figured (Fig. 71; broken anteriorly) shows well the differences from the Awamoa *apicalis.*

Proximitra partinoda n. sp.

Has the same slender shape as *apicalis,* but spire shorter. Suture much more weakly margined. Shell smaller. Axial sculpture obsolete on body whorl, the nodules becoming very fine and close on penultimate and finally vanishing altogether, leaving last whorl smooth and rounded except for a faint trace of the peripheral carina. Spire whorls angled below middle.

Height, 10.2 mm.; width, 3.8 mm.

Locality—Blue Cliffs, Otaio River (Upper Ototaran ?), type and two more shells; also Pareora River, blue clays (same horizon), two shells.

Type in Finlay collection.

Proximitra paucinoda n. sp.

Shell small, biconic. Embryo of two smooth whorls, as in *tumens.* Adult whorls four, rather flat, keeled almost at lower suture, body whorl sloping regularly from periphery to neck of canal, where it is slightly excavated. Axials about 11 per whorl, several times their width apart, very short, not reaching upper suture, and dying away just below periphery on body whorl; thin and sharp, but developed

on periphery into strong nodules, swelling out on each side of the ribs leaving a sharp central ridge. Numerous spirals with sublinear interstices cover whole surface; four are considerably stronger on periphery and have deeper interstices; spirals above keel becoming weaker and thinner, leaving an almost smooth band below suture, which is not margined. Aperture as in *tumens*, but narrower, and sides more parallel.

Height, 11.5 mm.; width, 5.3 mm.

Locality—Blue Cliffs, Otaio River (Upper Ototaran ?).

Type in Finlay collection.

Easily distinguished by its fewer and stouter nodules and low spire from the other species.

Parvimitra pukeuriensis n. gen. et sp. (Figs. 37-41).

Shell small, biconic, smoothish. Embryo of about two whorls, smooth, obscurely separated from adult whorls, initial coil very indistinct, closely wound. Subsequent whorls just over three, at first flat, later showing a keel a little above suture. Keel never very strong. Spire lower than aperture. 16-19 nodules per whorl on the keel, merely small tubercles, prolonged a small distance up and down to form short axials not reaching half way up shoulder, barely reaching lower suture. On body whorl axial ornament becomes practically obsolete, and there is usually only a smooth low keel. Spirals sub-obsolete, a few with linear interstices visible on base and on periphery. Aperture narrow, sides sub-parallel, angled above; beak short, un-notched. Pillar not excavated, with four sub-equal plaits, usually all oblique and sub-parallel, but occasionally the upper two more horizontal, the lower two sometimes a little weaker. Most specimens show persistent traces of irregular spiral anastomosing colour stripes.

Height, 7 mm.; width, 3.2 mm.

Locality—Pukeuri, sandy clays in road-cutting (Awamoan), type and numerous specimens. Also Awamoa (typical), Rifle Butts (five shells larger than Pukeuri specimens); and Target Gully (six shells; the common form from here is the next species).

Type in Finlay collection.

This is the species Suter used to identify as *Vexillum linctum* (Hutt.), which is a Pliocene *Microvoluta.*

This new genus is provided (with *pukeuriensis* as type) for a series of small species hitherto included in but disagreeing somewhat with *Proximitra* Finlay, 1926 (*Trans. N.Z. Inst.*, vol. 57, p. 410). They are very much smaller than typical *Proximitra,* lack the rather long and twisted beak, usually show weaker sculpture, and have the pillar plaits somewhat differently developed. *Proximitra* has them set on a slightly excavated pillar, the upper three much stronger than the lowest (which is sometimes sub-obsolete), and widely separated, the length of the pillar below the plaits considerably greater than that above. *Parvimitra* has an unexcavated pillar, four sub-equal plaits or the lower two a little weaker, all plaits close together, the pillar space below less than that above, or sub-equal to it. In *Parvimitra* may be included *Austromitra plicifera* Marwick, 1928 (*Trans.*

N.Z. Inst., vol. 58, p. 485; F. 129) from Whenuataru Peninsula, Chatham Islands, *Vexillum plicatellum* Marshall and Murdoch, 1923 (*idem.*, vol. 54, p. 123; Pl. 12, F. 3), from McCulloughs Bridge, and the new species described below.

On the other hand, *Mitra* (*Cancilla*) *armorica* Suter (*N.Z.G.S. Pal. Bull. No. 5*, p. 27; Pl. 12, Fig. 4), left by me under *Mitra* (*Trans. N.Z. Inst.*, vol. 55, p. 468; Pl. 50, Fig. 4a, b), is undoubtedly a *Proximitra*, agreeing exactly with *rutidolomum* the genotype in apex, aperture, and general sculpture, but more elate, and with the whorls not bulging at the shoulder and regularly rounded instead of squarely truncate or even concave.

Parvimitra scopi n. sp.

Differs from *pukeuriensis* only in having stronger and fewer nodules (12-14 per whorl), tending to become wider apart on body whorl; the keel on body whorl is stronger, and the shoulder not so steep.

Same size as *pukeuriensis.*

Locality—Target Gully shell-bed (Awamoan), type and numerous specimens.

Type in Finlay collection.

This is the common *Parvimitra* here, and does not seem to occur elsewhere. Six shells from this locality could not be separated from *pukeuriensis,* the rest all agreed in their stronger and fewer nodules. Possibly *scopi* and *ponsatanae* (next species) are facies-forms of *pukeuriensis,* but as the Target Gully and Ardgowan horizon is probably a little lower than the typical Awamoan Pukeuri beds, and the specimens are separable at sight, it is best to give each a name.

Proximitra ponsatanae n. sp. (Fig. 29).

Another species closely related to *pukeuriensis* and *scopi,* but having numerous irregular axials instead of nodules. About 21 axials per whorl, very irregularly developed, interstices much narrower; they begin half way down shoulder and reach lower suture, on body whorl they become weaker below periphery but do not die away, and reach down to canal. They are only very feebly developed into nodules on periphery. No spiral sculpture. Four pillar plaits, the upmost and lowest rather weak, the second top one strongest.

Height, 7.3 mm.; width, 3.7 mm.

Locality—Ardgowan shell-pit (Awamoan).

Type in Finlay collection.

Recalls *plicatellum* (M. & M.) but that species has spiral sculpture, a margined suture, and more distant axials.

Parvimitra subplicatellum n. sp. (Figs. 43, 44, 45).

Shell very close to *plicatellum* (M. & M.), but more squat, and with stronger spiral sculpture. Spire whorls vertically compressed, the angle considerably greater than in *plicatellum.* About 21 axials per whorl, interstices twice their width or more, instead of fairly coarse ribs with sub-equal or narrower interstices. Strong spirals with linear interstices cover whole surface; the spirals in *plicatellum*

FIG. 1.—*Murexsul scobina* n. sp.: holotype. × 2.3.
FIG. 2.—*Murexsul clifdenensis* n. sp.: paratype. × 2.
FIG. 3.—*Chicoreus* (?) *syngenes* n. sp.: paratype. × 1.4.
FIG. 4.—*Chicoreus* (?) *syngenes* n. sp.: holotype. × 1.4.
FIG. 5.—*Poirieria primigena* n. sp.: holotype. × 2.
FIG. 6.—*Crosseola sulian* n. sp.: holotype. × 3.
FIG. 7.—*Chicoreus* (?) *komiticus* (Suter): holotype. × 1.1.
FIG. 8.—*Murexsul clifdenensis* n. sp.: holotype. × 2.
FIG. 9.—*Pteronotus awamoanus* n. sp.: holotype. × 5.
FIG. 10.—*Dolicrossea awamoana* n. sp: holotype. × 4.
FIG. 11.—*Crosseola proerrata* n. sp.: holotype. × 12.5.
FIG. 12.—*Crosseola proerrata* n. sp.: paratype. × 12.5.
FIG. 13.—*Chicoreus* (?) *komiticus* (Suter): topotype. × 2.3.
FIG. 14.—*Murexsul* (?) *praegressus* n. sp.: holotype. × 1.5.

Face p. 64.

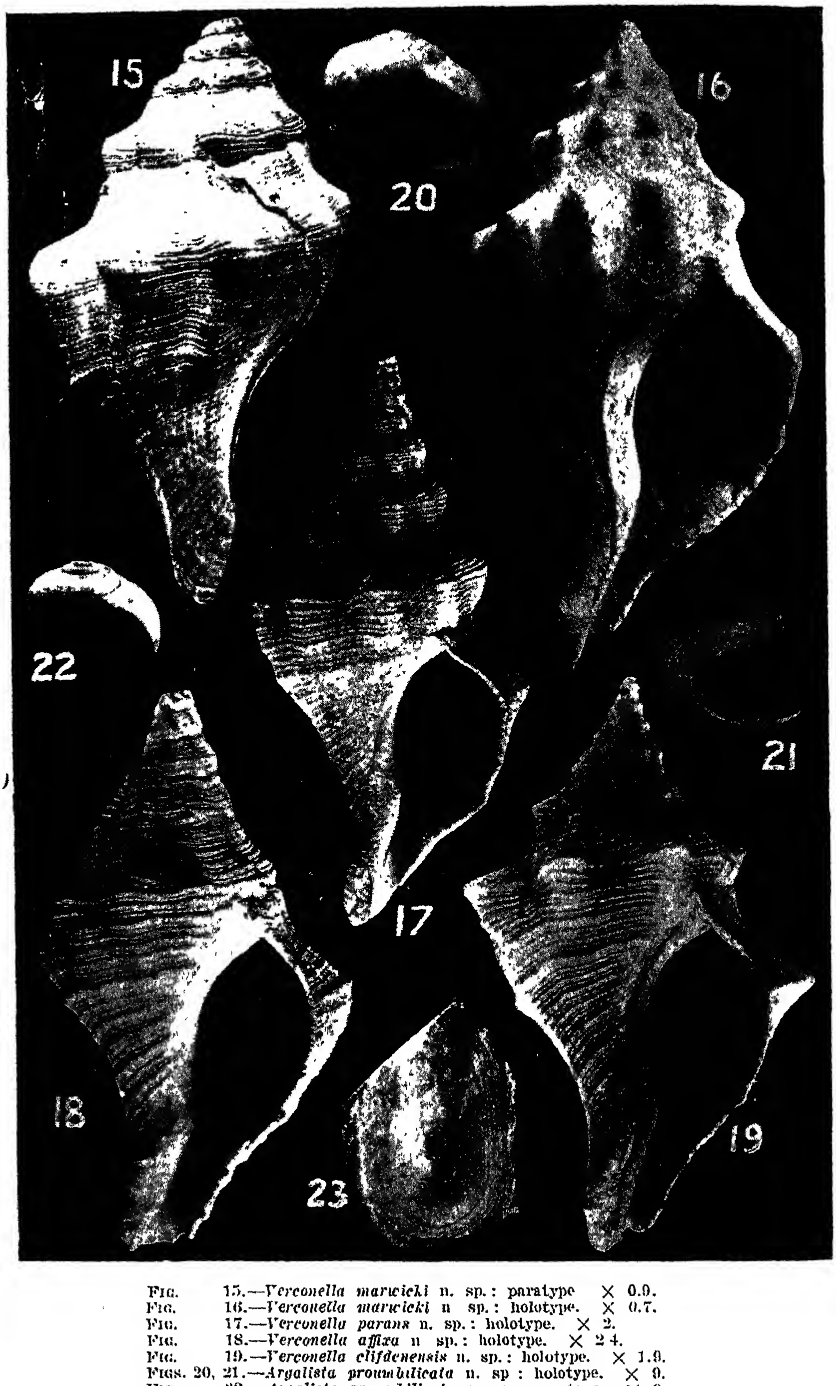


Fig. 15.—*Verconella marwicki* n. sp.: paratype × 0.9.
Fig. 16.—*Verconella marwicki* n sp.: holotype. × 0.7.
Fig. 17.—*Verconella parans* n. sp.: holotype. × 2.
Fig. 18.—*Verconella affixa* n sp.: holotype. × 2 4.
Fig. 19.—*Verconella clifdenensis* n. sp.: holotype. × 1.9.
Figs. 20, 21.—*Argalista proumbilicata* n. sp : holotype. × 9.
Fig. 22.—*Argalista proumbilicata* n. sp : paratype. × 9.
Fig. 23.—*Scutus petrafixus* n. sp.: holotype. × 0.7.

FIG. 24.—*Verconella* sp.: Kapiti Island. × 1.3.
FIG. 25.—*Dolicrossea clifdenensis* n. sp.: paratype. × 14.
FIG. 26.—*Dolicrossea clifdenensis* n. sp.: holotype. × 14.
FIG. 27.—*Verconella parans* (?) n. sp.: Pakaurangi Point × 2.3.
FIG. 28.—*Verconella allani* n. sp.: holotype. × 0.6.
FIG. 29.—*Parvimitra ponsatanae* n. sp.: holotype. × 3
FIG. 30.—*Pleia otaioensis* n. gen. et sp.: holotype. × 2.1.
FIG. 31.—*Cabestana debilior* n. sp.: holotype. × 1.
FIG. 32.—*Verconella mandarina* (Duclos): Kapiti Island juvenile. × 1.3.
FIG. 33.—*Merica pukeuriensis* n. sp.: holotype. × 5
FIGS. 34-36,—*Parvimitra plicatellum* (M. & S.): topotypes × 2.4
FIGS. 37-40.—*Parvimitra pukeuriensis* n. sp.: paratypes. × 1.9.
FIG. 41.—*Parvimitra pukeuriensis* n. sp.. holotype. × 1.9.
FIG. 42.—*Parvimitra allani* n sp.: holotype. × 1 7.
FIGS. 43, 44.—*Parvimitra subplicatellum* n. sp.: paratypes. × 1.8.
FIG. 45.—*Parvimitra subplicatellum* n. sp.: holotype. × 1.8.

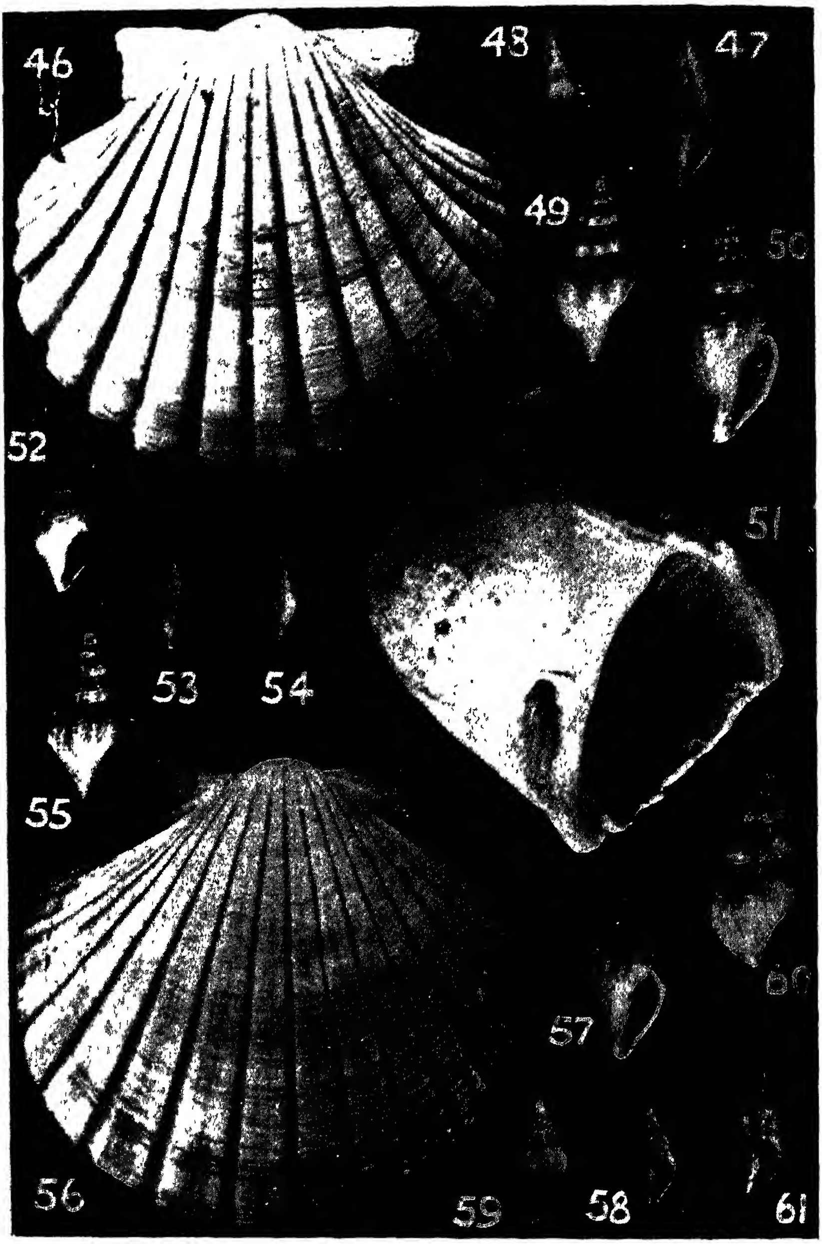


FIG. 46.—*Notovola tainui* n. sp.: holotype. × 0.7.
FIG. 47.—*Cordieria rudis* (Hutton): lectotype. × 1.6.
FIGS. 48-50.—*Cordieria rudis* (Hutton): topotypes. × 1.6 and 2.4.
FIG. 51.—*Magnatica fons* n. sp.: holotype. × 2.8.
FIGS. 52, 53.—*Cordieria huttoni* n. sp.: holotype. × 2.4 and 1.6.
FIGS. 54, 55.—*Cordieria huttoni* n. sp.: paratype. × 2.4 and 1.6.
FIG. 56.—*Notovola tainui* n. sp.: paratype. × 0.6.
FIGS. 57, 58.—*Cordieria haasti* n. sp.: holotype. × 2.4 and 1.6.
FIG. 59.—*Cordieria haasti* n. sp.: paratype. × 1.6.
FIGS. 60, 61.—*Cordieria verrucosa* n. sp.: holotype. × 2.4 and 1.6.
(FIG. No. 62 is accidentally omitted.)

FIG. 63.—*Barbatia awamoana* n. sp.: holotype. × 1.5.
FIG. 64.—*Barbatia awamoana* n. sp.: paratype × 1.5.
FIG. 65.—*Barbatia awamoana* n. sp.: paratype. × 2.6.
FIG. 66.—*Waimatea inconspicua* (Hutton), var.: McCulloughs Bridge. × 2.2.
FIGS. 67, 70.—*Proximitra tumens* n. sp.: paratype. × 3.6.
FIG. 68.—*Proximitra apicale* (Hutton): topotype. × 3.6.
FIG. 69.—*Proximitra tumens* n. sp.: holotype. × 3.6.
FIG. 71.—*Proximitra tumens* n. sp.: Awamoa. × 3.4
FIG. 72.—*Proximitra apicale* (Hutton): Pukeuri, senile. × 3.7.
FIG. 73.—*Proximitra apicale* (Hutton): Pukeuri, normal. × 3.6.
FIG. 74.—*Waimatea apicicostata* (Suter): McCulloughs Bridge. × 2.2.
FIG. 75.—*Cosa wanganuica* n. sp.: holotype. × 5.5.
FIGS. 76, 77.—*Cosa wanganuica* n. sp.: paratypes. × 5.5.
FIGS. 78-80.—*Cosa filholi* (Bernard): 60 fathoms, off Otago Heads. × 5.5.

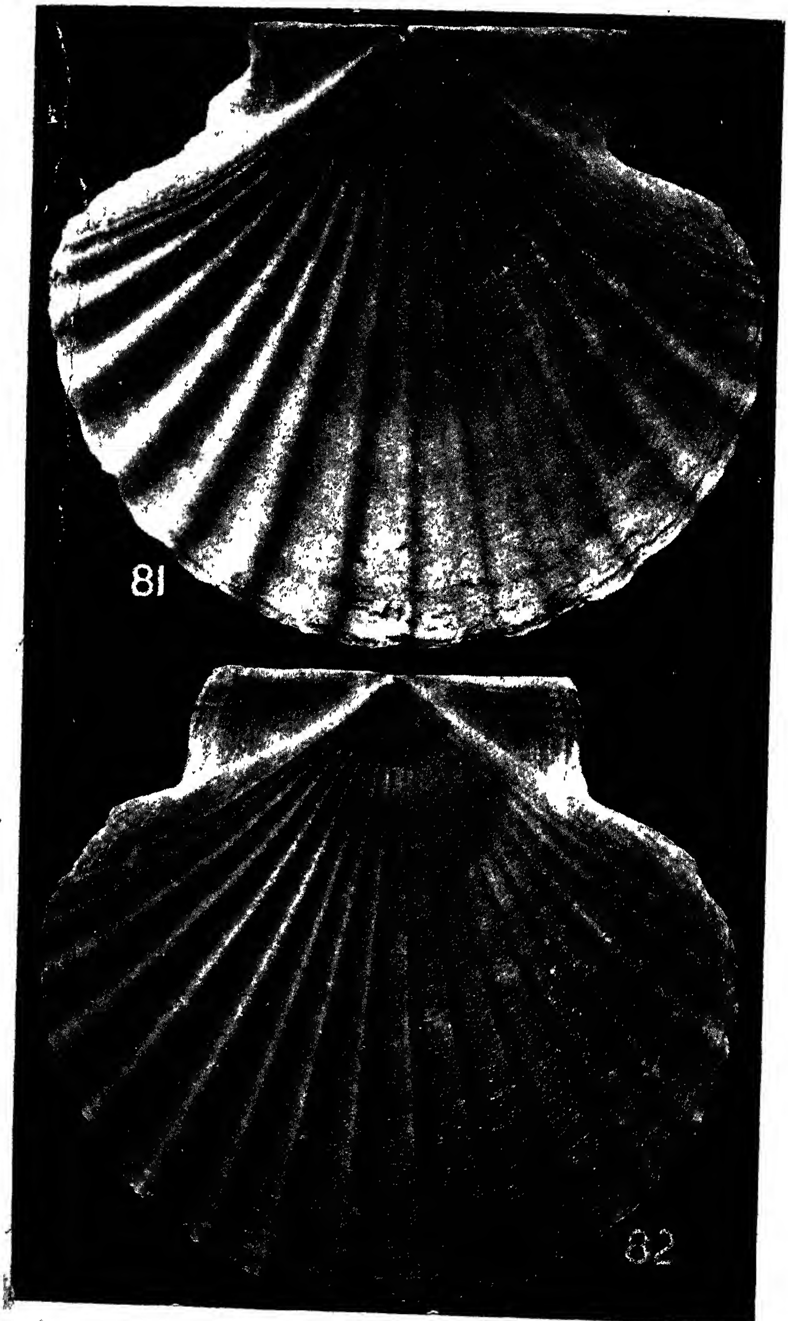


FIG. 81.—*Notovola tainui* n. sp.: holotype. × 1.2.
FIG. 82.—*Notovola novaezelandiae* (Reeve): 20-30 fathoms, off Otago Heads. × 1.

are similar, but very weakly indicated, often obsolete. Aperture and pillar similar but shorter.

Height, 5.7 mm.; width, 3.2 mm. (corresponding measurements for the smallest of the three topotypes of *plicatellum* here figured, 7 x 3.5).

Locality—McCulloughs Bridge greensand below limestone (Tahuian), type and several other specimens.

Type in Finlay collection.

There seems to be no intergrading between these two species; the squat spirally sculptured shells are easily separated from the taller and smoother ones. For comparison, topotypes of *plicatellum* are here figured (Figs. 34, 35, 36).

Parvimitra clifdenensis n. sp.

Rather similar to *plicatellum* and *subplicatellum,* but smaller, with different axials and whorl shape. The whorls are regularly almost flatly convex, no median shoulder swelling as in those two species, merely a very faint indication of a shoulder angle. Sutures sub-canaliculate, but hardly interrupting the straight spire outlines. In general proportions similar to *plicatellum,* not *subplicatellum.* Differs from both these in absence of spirals. About 23 axials per whorl, sub-linear ridges, four or more times their width apart, prominent from suture to suture on spire whorls, completely vanishing half way down body whorl. Aperture and plaits as in *pukeuriensis.*

Height, 4.9 mm.; width, 2.4 mm.

Locality—Clifden, band 7A (Hutchinsonian).

Type in Finlay collection.

The absence of spirals and the numerous un-noduled axials recall *ponsatanda* (which possibly developed through this species from *plicatellum*); the Ardgowan species, however, is larger, has a well-developed shoulder, and much thicker axials, which do not reach upper suture.

Parvimitra allani n. sp. (Fig. 42).

Shell more slender than the other species of this group. Embryo of nearly two smooth whorls, the initial turn rather depressed. Adult whorls just over four, convex with a median bulge, hardly shouldered. Axials about 17 per whorl, rather low and blunt, interstices narrower, restricted to first two whorls which they cross from suture to suture, strongest medially; last two whorls smooth except for growth lines and obscure spirals; these are faintly developed over whole surface, with linear interstices, much as in *plicatellum.* Suture margined by a low but distinct band. Body whorl and spire long for the genus; four regular oblique equidistant pillar plaits, the lowest somewhat weaker.

Height, 8.2 mm.; width, 3 mm.

Locality — McCulloughs Bridge greensands, below limestone (Tahuian).

Type in Finlay collection.

This considerably resembles a young *Waimatea,* and differs from all the other Parvimitras in its slenderness. Nevertheless, the charac-

ters of the apex, sculpture, suture, and canal seem to show closer alliance with *plicatellum* than with *inconspicua* and its relatives.

Waimatea amplexa n. sp.

Ancestral and very close to *W. inconspicua* (Hutton), from McCulloughs Bridge. Constantly more elongate and slender, and all examples seen are much smaller. The vestigial axials on the first adult whorl tend to be stronger and wider apart. The most marked difference is seen in the outline of the whorls at the sutures; in *inconspicua* there is a decided horizontal inturning just at suture so that the whorls appear somewhat staged, with a minute sutural platform, followed by a considerable convexity; in *amplexa* the whorls are tightly clasping, meeting in a steep angle, not staged, without a platform, and merely gently convex.

Height, 10.5 mm.; width, 3.7 mm.

Locality—Waihao Downs greensands, on the bank of the Waihao River (Bortonian), type and 5 more; also at the Abandoned Railway cutting (same horizon), one shell.

Type in Finlay collection.

This species is restricted to the Bortonian, whereas *inconspicua* is characteristic of the Tahuian. The latter species was recorded by Dr. Allan from Waihao Downs, but the present form was mistaken for it.

Waimatea apicicostata (Suter). (Fig. 74).

1917. *Vexillum apicicostatum* Suter, *N.Z. Geol. Surv. Pal. Bull. No. 5,* p. 27; Pl. 12, F. 5.

1926. *Conomitra apicicostata* (Suter): Allan, *Trans. N.Z. Inst.,* vol. 56, p. 341.

1926. *Waimatea apicicostata* (Suter): Finlay, *idem.,* vol. 57, p. 408.

The position of this species is unsatisfactory. It was described from Geol. Surv. Locality No. 479—Marly greensands, Waihao River: McKay. It is somewhat uncertain whether this collection is from the upper or lower Waihao greensands; McKay records a separate locality as No. 642, Waihao River Bridge, which is presumably McCulloughs Bridge, so that the inference is that 479 is the Waihao Downs greensand. McKay's remarks in the *Rep. Geol. Surv. Explor. for 1881,* p. 72, strengthen this supposition, and the types of two species described from here, *Hemifusus goniodes* Suter and *Clavatula mackayi* Suter seem to be from the Downs greensand rather than McCulloughs Bridge. On the other hand, *Surcula mordax* Suter, *Turris duplex* Suter, and a paratype of *Turris uttleyi* Suter all agree better with McCulloughs Bridge shells than with Downs specimens. If *Vexillum apicicostatum* is from the Downs, it apparently must be the same as my *W. amplexa,* just described, as this is the only *Waimatea* found here. But the figure does not look like *amplexa,* having the short spire and convex body whorl of *inconspicua.* Exactly similar varieties of *inconspicua* occasionally turn up at McCulloughs Bridge, and one of them is here figured for comparison (Fig. 66). If this is Suter's shell, then it can hardly be maintained as distinct from *incon-*

spicua. But his account of the sculpture seems to indicate a more strongly ornamented shell than *inconspicua,* which has only occasionally a few post-nuclear axials, and sometimes a few spirals on neck of canal, and 1-2 below suture. One specimen of a *Waimatea,* however, was collected at McCulloughs Bridge by Dr. Allan (Fig. 74), and this has, besides a more squat spire and inflated body whorl than any of the other forms, distinct spirals over the whole surface and well marked axials on all but last whorl. It seems preferable at present to identify this as *apicicostata,* and regard locality 479 as probably including two horizons, most of the species being Bortonian, but a few coming from a Tahuian band or locality. The matter, however, can only be cleared up by the Geological Survey.

Waimatea transilis n. sp.

Closely related to the Awamoan *othoniana* (Finlay), and ancestral to it. Spire lower, and body whorl relatively much larger and more inflated; whorls strongly instead of flatly convex. Ornament much weaker, shell almost smooth. The strong, close, reticulating axials on the early whorls of *othoniana* are absent, the merest trace of axial ribbing visible on only one specimen. Spiral sculpture much weaker, on spire whorls it is better developed on upper half instead of regular as in *othoniana,* practically absent on periphery; spirals on base numerous, low and rather broad, with linear interstices, instead of raised and rather distant ridges. Aperture somewhat wider, beak more quickly contracted. Other details same in both species.

Height, 10.8 mm.; width, 5 mm.

Locality—Otiake, sandy beds above limestone (Upper Ototaran), type and six others.

Type in Finlay collection.

This provides a bridge between *othoniana* and *apicicostata;* from the latter it differs in its weaker axials and stronger spirals and less sunken suture.

Verconella marwicki n. sp. (Figs. 15, 16).

Shell close to and probably ancestral to the Recent *adusta* (Phil.), but reaching a larger size, and more nodulous. On early whorls of *adusta* the axials are much more numerous and closer together, less than own width apart; in *marwicki* this is so for only the first post-embryonic whorl, the ribs rapidly becoming strong and distant, about twice their width apart; the closely costate appearance of *adusta* quite absent. The tubercles into which these ribs are raised are higher and much more regularly bluntly conical, not horizontally keeled by a peripheral rib; they are prolonged downwards on body whorl into rather narrowly raised ridges quite different from the wide undulations of *adusta.* Periphery lower down, on lower third of whorls instead of median. Spirals much lower and wider, separated by almost linear grooves, a broad and narrow one alternating, no strong raised ridges as in *adusta.* Shoulder clasping further up on previous whorl. Aperture perhaps a little longer. Other details as in *adusta.* Colour bands, as shown in a few specimens, paired, relatively much wider and less numerous than in *adusta.*

Height, 41 mm.; of spire, 16 mm.; width, 26 mm. (type). The species reaches at least 65 mm. height as shown by imperfect paratypes.

Locality—Clifden, band 6c (Hutchinsonian), type and several others; and band 7A (Hutchinsonian), two shells. Also two broken shells apparently of this species from the lower shell-bed, upmost Mt. Brown beds, Weka Pass.

Type in Finlay collection.

This seems to be on a different line from *marwicki* and *adusta*, and probably represents Powell's " Group A " which contains true *dilatata* Q. & G., and is " confined to deep water " with a " comparatively thin shell." In shape it considerably resembles *V. koruahinensis* Bart. & Powell, from Kaawa Creek, but has stronger, sharper and more compressed tubercles, and a much more prominent basal angulation.

From a horizon in the third bay at Clifden, somewhere between 6c and 7A, Dr. Thomson collected two fine specimens (in Dominion Museum collection) which show the senile characters well; the strongly keeled fasciole gives them a superficial resemblance to *Austrofusus magnificus* Finlay, from the same beds.

This is the " undescribed " species which Powell and Bartrum (*Trans. N.Z. Inst.*, vol. 60, p. 431) have stated to be the nearest relative to their *V. exoptata* from Waiheke Is.

Verconella parans n. sp. (Figs. 17, 27).

Directly ancestral to *clifdenensis*. Shell more slender, spire angle considerably smaller, body whorl not nearly so wide. Spines much smaller and less developed, mostly as blunt tubercles on axials, hardly at all vertically compressed, periphery generally with 2-3 strong spirals instead of one. Periphery submedian instead of near lower suture. Canal less bent to left, and fasciole weaker.

Height, 40 mm.; of spire, 19 mm.; width, 19.5 mm. (type). Largest specimen reaches 53 mm. in height.

Locality—Clifden, band 6B (Hutchinsonian), type and several others; also bands 6A and 4B (Hutchinsonian).

Type in Finlay collection.

In my collection is a shell from Pakaurangi Point (Fig. 27) which I tentatively identify as this species. I can find no separative characters except the protoconch, which is of only two whorls and smaller than that of *parans*. But the apex of *parans* is not constant in size; though always of the same general type, some specimens may have it up to twice as large as others. This is exactly what Powell has noticed (*Trans. N.Z. Inst.*, vol. 60, p. 61; Figs. 118-121; 1929) in the Recent *adusta*, and is a common feature in genera which produce several larvae in each ovicapsule. So, although the Pakaurangi shell has a smaller embryo, of fewer turns, than any Clifden specimen of *parans*, I prefer to leave it there till more than one specimen shows its constancy or otherwise.

The small size of the apex in this Pakaurangi shell and in *Siphonalia excelsa* Suter induced me to refer them to *Austrosipho* (*Trans. N.Z. Inst.*, vol. 57, p. 504; 1927) but now I very much doubt this.

Austrosipho has the same protoconch as true *Colus* (described by Grabau, whose account is quoted by me elsewhere in this volume), and there are rather characteristic differences in the ornamentation from *Verconella*. I cannot satisfactorily place *excelsa;* it seems not unrelated to such Balcombian species as *asperulus* and *styliformis* Tate, but these are not typical *Austrosipho*. The lineages in this group are most complex. If genera are to express lineages, I do not see how *Largisipho* Iredale (*Rec. Austr. Mus.*, vol. 17, No. 4, p. 182) can be maintained as distinct from *Austrosipho; L. spectanda,* the genotype is evidently a terminal Recent member of the Tertiary *roblini* line.

Verconella mandarina (Duclos). (Fig. 32).

This species occurs at Castlecliff, but I have not seen it from a lower horizon. Juveniles are common there and agree well with Recent juvenile shells, one of which (from Kapiti Island) is here figured. Powell (*Trans. N.Z. Inst.*, vol. 57, p. 556; 1927) gives Wanganui as the most northerly locality for this species known to him, but I have several typical shells from Kapiti Island.

Verconella falsa n. sp.

1926. *Verconella dilatata* (Q. & G.): Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 412; Pl. 20, F. 70; not of Q. & G.

Powell's work on the Recent Verconellas from the littoral down to 105 fathoms shows that I misidentified Quoy and Gaimard's species. I stated at the time that the identity of this species could not be settled till exact topotypes were dredged. Powell has now figured a 25 fathom shell (*Trans. N.Z. Inst.*, vol. 57; Pl. 30, F. 18; 1927) which may be taken as typical, and this does not agree with my Castlecliff shell. This has very fine spiral sculpture in comparison with *adusta* or *mandarinoides,* a very short canal, and incipient tuberculation on last three whorls. The tubercles are never much developed, and have not the characteristic double spiral ridge of the *dilatata* series; the whorls are very convex, with a blunt sub-angle above the middle.

Height, 117 mm.; of spire, 53 mm.; width, 60 mm.

Locality—Castlecliff "papa" (Castlecliffian).

Type in Finlay collection.

Verconella allani n. sp. (Fig. 28).

This is an interesting form ancestral to *falsa.* It has the same fine spiral sculpture and regular close axials (as in *mandarina*) on early whorls, but the subsequent axial sculpture is quite different, and at present unique in the genus. After the first 3-4 whorls, the close axials die away altogether, and the next two whorls are devoid of axial sculpture, regularly rounded, the even spiral sculpture interrupted only by growth lines. On the body whorl or just before it axial sculpture reappears again and remains up to aperture, but now there are no ribs but prominent tubercles (on the paratype they are much higher and stronger than on the figured type), much like those of *adusta,* 10-11 per whorl. Aperture as in *mandarinoides,* etc.

Height, 129 mm.; of spire, 56 mm.; width, 61 mm.

Locality—Nukumaru, "papa" band (Nukumaruan), type and one paratype, collected by Dr. R. S. Allan.

Type in Finlay collection.

The loss of axial sculpture on the median whorls is the most characteristic feature of this species, but it is also more slender than *falsa,* the whorls are more tightly clasping at the sutures, and the canal is longer. Apart from these differences, *falsa* might be regarded as an *allani* in which the change from simple axials to nodules took place without the intervention of a smooth space; *i.e.,* the stages of growth are telescoped. This is what one might expect in a descendant.

Verconella sp. (Fig. 24).

At Castlecliff, juveniles of two different species are common. One has very coarse spiral ridges and numerous close axial ribs; this I identify with *mandarina.* The other has much finer spirals and rather distant axial ribs (1½-2 times their width apart) on first 3¾ whorls, last whorl and a quarter without axials; the axials become slightly nodular on periphery of second whorl, and remain so till penultimate whorl, where the ribs tend to disappear, leaving only nodules, then these too disappear. The apex is large, of about four swollen whorls, the first somewhat planorbid but exsert, the tip minute, the others very globose and overhanging the normal conch. A single Recent shell (the one figured) from Kapiti Island shows exactly the same features, and almost certainly represents the same species. What that is I am not sure. The distant axials and other apical features indicate alliance with *V. rex* Finlay, but this species and the other benthal relatives of *dilatata* are always strongly keeled and have very prominent triangular vertically compressed nodules. Perhaps it is the young of *falsa,* but it seems too slender. It might equally well be a juvenile of *ormesi* Powell, which is the only species of this group in which axials soon become obsolete. Until they can be traced up to the adult, and the body whorl sculpture and proportions determined, it seems useless to attempt identification. *Ormesi* is much more slender than *falsa,* but very likely descended through it from *allani.*

Dimensions of figured specimen (in Finlay collection): Height, 55 mm.; of spire, 24.5 mm.; width, 23 mm.

Murexsul (?) **clifdenensis** n. sp. (Fig. 2, 8).

Protoconch polygyrate, of at least three smooth conical whorls, the tip minute (but worn), apparently ending in a faint sinusigeral varix; not like the apex I described for *octogonus* (*Trans. N.Z. Inst.,* vol. 57, p. 487; 1927). Adult sculpture follows immediately; 7 axials per whorl, stouter and more raised than in *octogonus* (which has 9 per whorl), and the hollows between deeper, so that the spirals are much more undulated than in *octogonus.* Spirals very dense and fine on shoulder, spreading out fan-wise at the varices, a few central ones stronger and further apart; 3 main spirals on body whorl, 1 on keel,

1 emerging from suture, and 1 a little below this, then a wide excavated space with only fine spirals, then one very strong oblique rib on neck of canal (occasionally with a much weaker one close to it just below), then fine spirals to fasciole which is but slightly stronger than the neck cord; between peripheral and lower sutural spirals there are 2 (closer to suture) stronger than the other interstitials, these appear just above suture on spire whorls. Covering whole surface between main spirals are fine raised threads of irregular width and development, but a space above and below peripheral keel is always free of all but the finest threads. Axials raised into sharp hollow spines on periphery and on neck cord, and to a less extent on other main spirals and fasciole; fine and numerous hollow curved lamellae on growth lines render all spirals rasp-like. Whorls (excluding apex) about 7, with a median keel, the shoulder sloping at about 30 degrees, straight below. A slight swelling margining suture below. Aperture not fully formed in any specimen, but probably like that of next species described. Pillar with a very strong twist and strong subangulation at inception of canal, which is short, only about half that of *octogonus.*

Height, 23 mm.; of spire, 9 mm.; width, 14 mm.

Locality—Clifden, band 6c (Hutchinsonian), type and 4 paratypes.

Type in Finlay collection.

This represents a different line from *octogonus,* but may be left under *Murexsul* till the group is revised.

Murexsul (?) praegressus n. sp. (Fig. 14).

Protoconch missing, but shell almost certainly of same group as and ancestral to *clifdenensis.* Apparently larger and with more even spiral sculpture. Axials and spines same in number and arrangement, except that spirals below periphery carry stronger spines. The same smoothish space above and below periphery, but elsewhere spirals are much more regularly arranged than in *clifdenensis;* 4 strong cords with narrower interstices below this space on penultimate whorl; 6-7 main spirals on body whorl with a weaker interstitial riblet between each pair; 2 spiny raised cords on neck of canal, close together, the lower stronger, less oblique than in *clifdenensis.* Aperture rather narrowly oval, with thick walls, everywhere projecting, strongly separated from body and parietal walls, channelled at periphery and at suture, with 7 internal denticles; pillar with same strong twist and angulation as *clifdenensis,* with a prominent tubercle on inner lip at end of twist and a fainter one above. Canal as in *clifdenensis,* but fasciole more curved and spreading, enclosing a deep umbilical perforation.

Height, 33 mm.; of spire, 14 mm.; width, 22 mm.

Locality—Clifden, band 3 (Hutchinsonian).

Type in Finlay collection.

The two denticles on the columella are highly abnormal in the genus; they are not seen on any specimens of *clifdenensis,* but probably none of these are fully adult.

Murexsul scobina n. sp. (Fig. 1).

Very like *praegressus*, but smaller, more slender, with 8 axials per whorl. At first sight the specimens seem to be juveniles of *praegressus*, but the number of axials is constant in all specimens seen, the canal is longer, the umbilical chink practically absent, and the spines on all but the peripheral rib are less prominent. The spiral sculpture is different, every fourth rib being stronger, and all the spirals are minutely and densely covered with tiny hollow foliations, giving a very file-like surface to the shell; 3 central spirals on shoulder are rather stronger. Two spiral cords on the whorls (on keel and near lower suture) are generally much stronger than the others. Three stronger oblique raised cords on neck of canal, the two top ones distant and always the most prominent, the lowest close to the median one, and sometimes inconspicuous.

Height, 18 mm.; of spire, 7.5 mm.; width, 10 mm.

Locality—Clifden, bands 4B (3 shells), 6A (type and 2 others), and 6B (1 shell). Also one shell from Target Gully.

Type in Finlay collection.

Two of the specimens from 4B (width about 28 mm.) indicate that this species reaches a much larger size—comparable with *octogonus*, of which this is probably an early ancestor. Unfortunately the protoconch is absent in all specimens, but I think it would prove to be paucispiral and quite different from *clifdenensis* and *praegressus*. The arrangement of spiral sculpture, especially the canal cords and the two prominent spirals on upper whorls is so like *octogonus* that I have little hesitation in referring it to this line.

This type is not unrelated to such Australian Tertiary forms as *Murex eyrei* Ten.-Woods (Table Cape) and *Rapana aculeata* Tate (Muddy Creek), but these species have different whorl proportions, a relatively higher and wider spire, different spines, and probably a larger embryo.

Chicoreus (?) komiticus (Suter). (Figs. 7, 13).

1917. *Murex zelandicus* var. *komiticus* Suter, *N.Z. Geol. Surv. Pal. Bull. No. 5*, p. 37; Pl. 4, F. 21.

When Suter described this Pakaurangi Point shell, it was mostly embedded in matrix, as shown by his figure, and no attempt was made to remove this. Suter was apparently quite satisfied that the fractured section exposed indicated alliance with the Recent *zelandicus*, but the details of the sculpture should have made him suspicious. When examining the holotype in the Otago Museum, I took the opportunity of removing the soft matrix and exposing the back of the shell. The figure of this now presented (Fig. 7) will sufficiently indicate how far from the mark was Suter's guess. The species is generically distinct from *Poirieria zelandica* (Q. & G.), and represents a type of *Murex* not hitherto found in New Zealand. The misleading comparison makes Suter's description worthless, and the species may be redescribed as follows:

Protoconch polygyrate (mostly missing in all specimens seen), conical, of several smooth almost flat whorls, with a curious lamellar keel exactly at the suture, jutting over the following whorl, termina-

tion obscure, but apparently sinusigerid. 5½ adult whorls, at first convex, then subangled, then bluntly keeled below middle, body whorl with a strong but not sharp keel. Axials 12 on first whorl (no varices), extending evenly across whorl, interstices about same width; varices develop on next whorl (3 per whorl), and become gradually stronger and stronger till on body whorl they are prominent and thick, rising suddenly and concave behind, sloping gradually but ending in a sharp edge in front; 2 axials between varices, at first equidistant and little different from the varices in size and shape, but they gradually shift forward (toward the anterior varix), the front axial diminishes, and the hinder one increases in size, till on the penultimate and especially body whorl there is apparently only one large central nodule between varices, with remnants of an axial prolongation above and below it, the front axial being now represented only by a thin ridge close to the anterior varix. Varices markedly prolonged on to base and jutting out as former ends of canals. Spirals at first 4 per whorl, equidistant, but the topmost one (on shoulder) weaker, gradually more and more spirals are intercalated till whole surface is covered with dense spiral sculpture, 2 more prominent on periphery and about 6 below, and 3-4 on shoulder; between these is a finer interstitial riblet, and between these again 1-3 very fine threads, the interstices irregular but mostly wider; the whole finely netted by hair-like axial threads. On the varices the main spirals are much stronger and raised into sharp narrow spines (mostly broken off), triangular and hollow in front; the peripheral spine is especially long and strong, on their backs they bear radiating distant narrow ridges. Three stronger cords with stronger spines on neck of canal, the upper two more distant. Aperture as described for *praegressus,* but more circular, lips not so thick and projecting (the inner one hardly separated from body whorl), the same two denticles on inner lip, but weaker. A distinct but small umbilical chink, fasciole strong, broken up by prolongation of varices.

Two other specimens from Pakaurangi Point are in my collection, one of these is here figured (Fig. 13) to show the normal appearance of the species. Its dimensions are: Height, 31 mm.; of spire, 13 mm.; of aperture, 10.5 mm.; width. 22 mm. The type is somewhat abnormal in its deeper sutures and excessively spinose condition.

The generic placing of this and the following species is difficult. To an austral worker the Muricoid genera are in a very unsatisfactory state. Cossmann's treatment in the *Ess. Pal. Comp.,* vol. 5, is obviously inadequate, Harris's locations of Australian Tertiary species need revision, Dall's works are concerned more with American species, and the only trustworthy general review commonly available is Iredale's sketch in *Trans. N.Z. Inst.,* vol. 47, pp. 467-471; 1915. This does not pretend to be exhaustive, and merely mentions types of genera, so that I find it very difficult to locate species that do not belong to *Murexsul* or *Poirieria. Komiticus* and the next species are obviously related to such Tertiary Australian species as *lophoessus* Tate (*Trans. Roy. Soc. S.A.,* vol. 10, p. 98; Pl. 2, F. 5; 1888) and two allied new species from the Abbatoirs Bore, Adelaide; such a Recent species as *turbinatus* Lamk. seems also connected. They are not *Murex* s. str., *Hexaplex,* or *Pteronotus,* so for the preesnt I leave

them in *Chicoreus,* the fourth of the "outstanding genera" mentioned by Iredale (*l.c.*, p. 469), though the resemblance to *ramosus* L., the genotype, is but faint.

Chicoreus (?) syngenes n. sp. (Figs. 3, 4).

This is so closely allied to *komiticus* that it can best be described by comparison—for that reason I have given a very full description of *komiticus.* Apex worn, but enough remains to show that it was of same style. Same shape and size, and same arrangement of sculpture. Peripheral spikes not so long and strong, not hollow (closed up by shell substance), with much weaker radiating ridges on their backs. Varices less conspicuous, especially on early whorls, less raised and not concave behind; the anterior of the two intermediate axials disappearing more completely, hardly a trace left on body whorl. Only one prominent oblique rib on neck of canal, but this is much thicker and stronger and more spinose than any of the three in *komiticus,* and has only fine spirals on each side of it.

Height, 32 mm.; of spire, 12 mm.; of aperture, 11 mm.; width, 20 mm.

Locality—Clifden, band 6c (Hutchinsonian), type and one other. Also one much rubbed shell from band 3.

Type in Finlay collection.

Poirieria primigena n. sp. (Fig. 5).

Directly ancestral to the Recent *zelandicus* Q. & G. Differs at sight in much lower position of keel, which is below middle of whorls instead of above. The whorls are consequently less tabulated and more pagodiform. These differences are constant, but otherwise the species are exactly the same. Evolution in the sculpture of this genus seems to have been at a standstill since our first knowledge of it in New Zealand.

Height, 38 mm.; of spire, 13 mm.; of aperture, about 12 mm.; width, 28 mm.

Locality—Otiake, sandy beds above limestone (Upper Ototaran), type and three fragments. More or less well preserved specimens also from Blue Cliffs and Pareora River (same horizon), Target Gully, Ardgowan, and Pukeuri (Awamoan).

Type in Finlay collection.

P. zelandica persists downwards at least as far as the Nukumaruan, a typical specimen being in my collection from Maraekakaho, Hawke's Bay. Where the break between the two species occurs I am not certain. *Primigena* is a very old species, Tahuian and Bortonian specimens (McCulloughs Bridge, and Abandoned Railway, Waihao Downs) being inseparable from the Otiake type; the apex appears to be smaller but is worn.

Pteronotus (s. str.) **laetificus** n. sp.

Shell large, only body whorl remaining. Three varices on this, thick and wedge-like, outline fairly regularly convex, apparently not spinose except at periphery, where there is a single strong broadly triangular projection, quite flat in front, with no trace of a groove, merely triangular growth lines; slightly angled behind. A single

stout but low and blunt elongated tubercle midway between varices. Heavy, low, and not prominent spiral cords over whole surface, about 14 in number, weaker on shoulder. Aperture rather narrowly oval, outer lip more convex than inner one, channelled above, leading into a fairly long open (? — the sole specimen has the lips of the canal broken) canal. Outer lip adpressed to flange, its margin little but distinctly raised, then rapidly contracting anteriorly to a blunt angulation on which are 8 short stout distant tubercles.

Height (of body whorl), 48 mm.; width, 41 mm.

Locality—Clifden, band 7c, close to band 8 (Hutchinsonian).

Type in Finlay collection.

Nothing like this has previously been seen from New Zealand, though I have fragments of a second new species of this group from Target Gully. *Laetificus* does not belong to the group containing the Recent Tasmanian *triformis,* but rather to that of the Balcombian *calvus* Tate, which is perhaps allied to the Chinese *pinnatus* Wood, the genotype of *Pteronotus.* The New Zealand shell is much larger and wider than *calvus.*

Pteronotus (Pterochelus) awamoanus n. sp. (Fig. 9).

Shell extremely close to the Recent *eos* (Hutton), but much smaller, and more slender, the two main keels closer together. Perhaps the best separative feature is the outer lip of the aperture, which in *eos* stands out at right-angles to the frill and is merely crenulated; in *awamoanus* it is effuse and flexed over till it is almost parallel to frill, and carries 5 teeth inside, remarkably solid for so small a shell. That portion of the outer lip between spike and suture is also markedly more steeply descending in *awamoanus.* Protoconch paucispiral, almost the same as in *Murexsul octogonus.*

Height, 16.6 mm.; of spire, 7.5 mm.; width, 8 mm. (type).

Height, 10.5 mm.; of spire, 4.5 mm.; width, 5 mm.; (paratype).

Locality—Target Gully shell-bed (Awamoan), type and 14 more or less fragmentary specimens. Also Ardgowan.

Type in Finlay collection.

The Castlecliffian *P. zelandica* (Hutt.) (*Typhis*), which intervenes between this species and *eos* is more different from them both than they are from each other, but it seems probable that it belongs to a different line, and that an *eos* type also occurs at Castlecliff.—I have no specimens, but I think there is one in the Geological Survey collection.

Zeadmete pliocenica n. sp.

Shell very close to the Recent *Z. trailli* (Hutton), and evidently directly ancestral to it. The chief difference is the possession of a well-marked shoulder a little below the suture (much as in *Oamaruia*), so that the whorls are quadrate, with vertical sides and an almost horizontal platform above; *trailli* has no angle, the whorls regularly convex, the body whorl quite ovate. Sculpture stronger, the cords being alternately weaker and more prominent, while in the Recent species they are less conspicuous and more even. Aperture relatively narrower, and the pillar plaits weaker, especially the median one.

Height, 9.3 mm.; width, 4.6 mm.

Locality—Castlecliff "papa" (Castlecliffian), type; also Petane (Nukumaruan).

Type in Finlay collection.

Zeadmete miocenica n. sp.

This merely carries to a further degree the differences from *trailli* shown by *pliocenica.* The shoulder is still sharper, and a little lower down. The peripheral cord and the one below it are more prominent and further separated than the others, giving a bicarinate appearance to the whorls, while in *pliocenica* the four main cords on the vertical part of the whorls are equal and practically equidistant. The pillar plaits are still weaker; the lowest (which is really merely a sharp-edged twist of the pillar in *pliocenica* and *trailli*) is barely evident, and the two upper ones are feeble, almost horizontal and close together, much like the plaits in the Turrid genus *Mitrithara.* Apex as in the other two species, of about 1¼ whorls, smooth and polished, upright, loosely coiled, the tip prominent and globose; marked off (but not prominently) from adult whorls by a very faint varix.

Height, 5.6 mm. width, 3 mm. (probably not fully grown).

Locality—Pukeuri, sandy clays in the road-cutting (Awamoan), type and one other; also Rifle Butts (Awamoan), two shells.

Type in Finlay collection.

Oamaruia (?) nodus n. sp.

Shell ovate, regularly and closely fenestrate. Embryo smooth and polished, of about 2¼ whorls, well and somewhat flatly coiled, vertically compressed, the top flattened and somewhat planorbid, the tip adpressed but prominent. A few curved axial riblets intervene between the faint closing varix and the true adult sculpture. This consists of spiral cords and stronger axial ribs, both numerous. There are at first 4 spirals, 1 on shoulder, other 3 below; these increase and become alternately stronger and weaker and about their own width apart (about 11 altogether on penultimate whorl; about 27 and half-a-dozen finer canal threads on body whorl). Axials 22 on body whorl, sharp, twice their own width apart or more, slightly sigmoid, extending almost undiminished from suture to base of canal; the two top spirals are more crenulated than the others by the tops of the axials. Outer lip and base of pillar broken away. Pillar plaits three, the lowest being on the twist of the canal, the upper two strong, sharp, oblique, and rather distant; weak ridges and grooves are intercalated between the plaits towards their extremity. Apparently a decided beak present.

Height, 11 mm.; width, 5.5 mm.

Locality—Otiake, sandy beds above limestone (Upper Ototaran).

Type in Finlay collection.

This is an anomalous form. It does not match with any New Zealand or Australian species that I know, and is temporarily referred to *Oamaruia* on account of the strong pillar plaits, but the shape and sculpture are more like *Zeadmete;* the embryo is not in accord with either of these groups.

Merica pukeuriensis n. sp. (Fig. 33).

Shell ovate, rather rotund, much the shape of a *Bonellitia,* but with a straight unexcavated pillar and different apex. Protoconch polygyrate, of 3½ smooth convex and shining whorls, well coiled, with rather deep sutures, the tip small, flattened, almost planorbid, the last ¼ volution with three keels, the upmost on the shoulder and very weak, the median one at the peripheral angle and strong and sharp, the lowest midway between this and suture, not so strong. With the inception of axial sculpture these keels become the three main (and on first whorl only) spirals in the adult sculpture; on the second whorl a slightly weaker spiral is intercalated between each, while on the third and last shell whorl the spirals become subequal, about 15 in all, narrow and raised, 2-4 times their own width apart. The topmost spiral on all whorls marks a sharp raised ridge between which and suture there is a deep sunken channel crossed only by lamellar axial ridges. Axials 16 per whorl, extending across the sutural ditch as irregular low lamellae, thence passing strongly from the bordering keel to the base, weakening slightly near end of canal; they are slightly oblique backwards, strong but narrow, about three times their width apart, undulating the four top spirals (especially the close topmost two), but not much affecting the others, hardly tubercular at intersections. Aperture trigonal (outer lip incomplete), horizontal at the suture, thence broadly and regularly curved to meet pillar in a point, canal almost absent, vertical and open. Three pillar plaits, progressively stronger posteriorly, subequidistant and very oblique. Basal fasciole marked by a very slight swelling.

Height, 13 mm.; width, 9 mm.

Locality—Pukeuri, sandy clays in road-cutting (Awamoan).

Type in Finlay collection.

This seems not distantly related to the common Australian Kalimnan *Cancellaria wannonensis* Tate (*Trans. Roy. Soc. S.A.*, vol. 11, p. 156; Pl. 8, F. 11; 1889), which in turn is obviously ancestral to the Recent *undulata* Sow., common in New South Wales and Tasmania. At first sight the excavated sutures are more reminiscent of *spirata* Lamk. and *lactea* Desh. (= *laevigata* Sow.), but the protoconchs of these two Australian species are large and paucispiral, like *Maorivetia* Finlay. *Wannonensis* and *undulata* have a flat platform instead of an excavation at the suture, but otherwise the type of ornament is identical, and their apices are the same as in *pukeuriensis,* except in being more exsert and lacking the closing keels—these are not vital differences. They are longer shells, with a better developed anterior beak, but the similarity is sufficiently close to associate the New Zealand species with them.

Judging from the figure and description, I should say that *Admete maorium* Marshall and Murdoch (*Trans. N.Z. Inst.*, vol. 53, p. 82; Pl. 18, Figs. 7, 8; 1921), from Target Gully, is close to *pukeuriensis* and certainly congeneric with it. I have seen no specimens (the type is apparently unique), but the same kind of sculpture and sutural excavation are evident from the figure, though it was a more juvenile shell than *pukeuriensis.* It differs in its stronger spiral sculpture and fewer axials (12), forming rather deep square pits between them.

These shells are widely removed from *Voluta reticulata* L., the genotype of *Cancellaria*. Following Cossmann in the meantime, I have placed them in *Merica* H. & A. Ad. (the type of which he gives as *melanostoma* Sow.), for which he used and figured *wannonensis* as a "plesiogenotype," but they do not fit very well. In the absence of comparative Recent material, I am unable to suggest a better location.

Uxia naroniformis n. sp.

Shell much like *Narona* in form, with sub-spiny sculpture, and produced body whorl and beak. Embryo tiny, paucispiral, of 1¼ loosely coiled smooth and shining whorls, the tip bulbous, prominent, set askew and slightly inrolled; not well marked off from adult sculpture. Three main narrow and sharp spiral cords on spire whorls, the upper two twice as far apart as lower two; 5 more equally prominent cords on body whorl, all but the topmost one equidistant and 4-5 times their width apart; on the shoulder, in interstices, and on canal are a few distant linear spiral threadlets. About 12 axials per whorl, stout and blunt, hardly oblique, antecurrent on shoulder, and rapidly diminishing towards suture, continued over body whorl and base, vanishing only at extremity of canal, 2-3 times their width apart; intersections of spirals and axials marked by sharp prickles, especially on two top spirals. Adult whorls 5, strongly shouldered at upper three-quarters, platform gently sloping, sub-vertical below. Last whorl long, about three-fifths of entire shell. At irregular distances there are strong flattish varices, 3 on the actual specimen, 1 just before the unformed outer lip; they are the general shape of the axials, but stronger and wider and more prominently antecurrent on shoulder. Aperture elongated, beak rather long, canal open, bluntly pointed, not channelled. Parietal wall smooth; three strong equal and equidistant pillar plaits; a strong basal fasciole.

Height, 16 mm.; width, 7.5 mm.

Locality—Rifle Butts, sandy clays (Awamoan).

Type in Finlay collection.

Quite close in details to the Tahuian *Uxia marshalli* Allan, though at first sight superficially different in the unchannelled suture. The number and the arrangement of the spiral and axial ribs are the same, but *marshalli* has much thicker and more prominent interstitial spirals, a channelled suture so that tops of axials project as blunt points, a shorter body whorl and beak, weaker fasciole, and less oblique plaits on the columella.

Uxia marshalli Allan.

1926. *Uxia* (?) *marshalli* Allan, *Trans. N.Z. Inst.*, vol. 56, p. 342; Pl. 77, Figs. 3a, b.

This is very close to the Australian Balcombian *Cancellaria epidromiformis* Tate and *exaltata* Tate (*Trans. Roy. Soc. S.A.*, vol. 11, p. 154; Pl. 8, Figs. 9, 10; 1889), having the same channelled suture, and arrangement of spiral and axial ribs (the latter more numerous on the Australian species), but a considerably lower spire; the Balcombian species have the appearance of being drawn out and

unwound, so that more spirals show on the spire whorls (5 instead of 3). They also have a much larger apex, though of exactly the same style. The parietal plait is irregularly developed but present in all these species; *naroniformis* does not show it, but is not quite adult.

In the absence of specimens of the genotype of *Uxia* Jousseaume, 1888 (*Cancellaria costulata* Lamk.; Eocene, Paris Basin) I am not certain that these austral species are correctly placed generically. Cossmann's figure (*Ess. Pal. Comp.*, livr. 3; Pl. 1, Figs. 16, 17; 1899) of the genotype has a different look, with its apparently more symmetrical and larger apex, weaker spiral sculpture, and widely open, not pointed, distinctly shallowly notched anterior canal; but on the other hand, several of the species illustrated as *Uxia* by Cossmann in the *Icon. Comp. Coq. foss. l'Eogene Env. Paris*, Tome 2; Pl. 47 (*e.g.*, Figs. 212-4, 7, and 12) are so like *exaltata* and *marshalli* that it seems unwise to separate the austral forms till actual specimens are available.

Genus **Borsonia** Bellardi.

All the New Zealand species of this genus have a tiny 2-whorled smooth protoconch, the tip minute, and the second whorl somewhat globular, abruptly ceasing before adult sculpture begins. All have similar columellar plaits—2 in number, very narrow and rather distant, weak at the extremity, higher and sharper within the aperture.

Two generic divisions are represented in New Zealand, one of Surculiform species which seem to be true *Borsonia*, the other of more Mitromorphoid shells, which may be classed under *Cordieria* Rouault. The members of the former occur in the Tahuian, Ototaran, and Hutchinsonian, those of the latter are as yet known only from the Tahuian in New Zealand—they seem to agree very well with the shells figured and described by Cossmann and Dall as typical *Cordieria*.

All the Australian Tertiary and Recent species of this group appear to be true Borsonias. *Borsonella* Dall and *Paraborsonia* Pilsbry are unrepresented in New Zealand.

The two divisions as represented in New Zealand may be separated thus:—

Sinus rather deep, sinus area between peripheral keel and strong sutural cord well excavated, so that body whorl appears keeled and tops of axial ribs are hollowed off	*Borsonia*
Sinus shallow and wide, sinus area between peripheral keel and weaker sutural cord hardly excavated, so that body whorl is bluntly keeled and axial ribs diminish regularly on shoulder	*Cordieria.*

KEY TO *BORSONIA* SPECIES.

(Spiral ornament on all is of same type, *i.e.*, 4 wavy cords between keel and lower suture, the upper two on the keel and separated merely by a groove. Suture margined by a stout swelling increasing in prominence as growth proceeds).

6-7 axials per whorl, interstices wider	*zelandica* Marshall.
9-10 axials per whorl, interstices subequal.	
Shell moderately large (over 15 mm.), spire equal to aperture; axials knobby and squarish on spire whorls, extending over only lower half or less ..	*mitromorphoides* Suter.
Shell small (under 10 mm.) and much narrower, spire higher than aperture; axials longer and more rib-like, extending over lower two-thirds of spire whorls	*clifdenensis* n. sp.

Borsonia clifdenensis n. sp.

Shell rather small, very like *Drillia callimorpha* Suter in shape. Embryo somewhat worn, but of 1½ smooth whorls, with 1 or 2 closer axials between it and true sculpture. Adult whorls 6, medially carinate, shoulder lightly concave, sloping in below. Nine axials per whorl, reaching from lower suture to half way up shoulder, and nearly down to where base narrows in to canal, interstices 1½ times as wide; only moderately tubercular on keel. A strong swelling with a medial ridge margining suture, shoulder smooth, 4 spirals from keel to suture on spire whorls, about 11 down to canal on body whorl (interstices 2-3½ times as wide), neck of canal with numerous finer and closer spirals. Spire considerably longer than aperture, slender. Sinus Surculiform, moderately deep, growth lines distinct. Fasciole moderately prominent. Pillar with two plaits, rather high up, the lower very weakly developed.

Height, 9 mm.; of spire, 5.3 mm.; width, 3.8 mm.

Locality—Clifden, band 6c (Hutchinsonian).

Type in Finlay collection.

Of the *mitromorphoides* style, but much smaller, with weaker sculpture and different proportions.

Key to *CORDIERIA* Species.

Shell rather slender, spirals thin but fairly prominent, with wider interstices, 2-3 better developed on peripheral keel, about 8 on penultimate whorl— 9 axials per whorl	*huttoni* n. sp.
Shell stout and rather squat, spirals thickish, with linear interstices, very low and weak except for 2-3 more prominent on tops of ribs on peripheral keel—	
6-7 axials per whorl, very stout and knobby	*verrucosa* n. sp.
9 axials per whorl, shell same shape as above	*rudis* Hutton.
10-12 axials per whorl, shell shorter and wider	*haasti* n. sp.

Cordieria rudis (Hutton). (Figs. 47, 48, 49, 50).

1885. *Clathurella rudis* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 328.

1915. *Mangilia* (*Clathurella*) *rudis* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 39; Pl. 8, F. 14.

1917. *Borsonia* (*Cordieria*) *rudis* (Hutton): Suter, *idem.*, *No. 5*, p. 84.

This species is restricted to the Tahuian stage, and has not been found elsewhere than at McCulloughs Bridge, where it is, though not

plentiful, the most common *Cordieria*. In the coaeval Hampden beds no Cordierias have been found, but one true *Borsonia,* which genus in turn seems to be absent from McCulloughs Bridge.

Hutton and Suter both confused two species under *rudis;* Suter selected a holotype from Hutton's five specimens in 1915, but amongst the paratypes were two specimens of the species now separated as *haasti.*

That four species of *Cordieria* should occur in the Upper Waihao greensands at McCulloughs Bridge, and none in the lower greensands at the Waihao Downs is remarkable, as Dr. Allan has already noted (*Trans. N.Z. Inst.*, vol. 57, p. 289; 1926).

Cordieria haasti n. sp. (Figs. 57, 58, 59).

Shell small, wide, very squat. Embryo tiny, 2-whorled, mamillate, asymmetrical, the nucleus decidedly lateral. Spire a little lower than aperture, outlines straight, angle about 50 degrees. Whorls short, bluntly sub-medially angled, shoulder a trifle concave, sloping steeply in below. Suture well impressed, wavy, margined by a cord below. 10-12 axials per whorl, knobby and swollen on spire whorls and periphery of body whorl (interstices half as wide), absent on upper half of shoulder, suddenly diminishing below periphery to low narrow ridges persistent down to inception of canal. Whole surface with spiral cords, the strongest margining suture below, 3-4 narrow weak cords on shoulder, 4 strong ribs on remainder of spire whorls and on periphery of last whorl, all these with linear interstices; remainder of last whorl with much weaker, almost flat irregular cords, a trifle stronger and very narrow on canal, interstices of varying width. Aperture sharply pointed and wide above, thence gradually tapering to a short open canal, not notched or truncated. Pillar straight, strongly sloping to left, gently and evenly a little twisted throughout its length. Two parallel gently sloping plaits at upper third of pillar, low, but strong and rather sharp, the upper slightly stronger. Sinus very shallow and gently rounded, situated on shoulder and sutural cord.

Height, 9.5 mm.; of aperture, 5.5 mm.; width, 5 mm.

Locality — Upper Waihao greensands, McCulloughs Bridge (Tahuian).

Type in Finlay collection.

Differs from *C. rudis* in lower spire, squat shell, closer axials, especially on spiral whorls, and coarser peripheral spirals.

Cordieria verrucosa n. sp. (Figs. 60, 61).

Shell small, shape of *C. rudis*. Embryo lost. Spire taller than aperture, outlines straight, angle about 35 degrees. Whorls bluntly angled at upper third, shoulder concave, sloping steeply in below. Suture rather hidden, hardly wavy, weakly margined below. Seven axials on last whorl, 8 and 9 respectively on the two preceding; very warty and swollen on spire whorls and periphery of body whorl (interstices of equal width), dwindling regularly and rapidly below periphery, and absent on lower half of base and upper half of

shoulder. Whole surface with weak spirals, two on periphery stronger and wider apart, the swelling below suture with a median sharp cord, elsewhere (especialy on shoulder), very weak. Aperture pyriform, rapidly attenuated to a very short canal. Pillar, plaits, and sinus as in previous species, but plaits a little lower down.

Height, 12 mm.; of aperture, 5.5 mm.; width, 5 mm.

Locality — Upper Waihao greensands, McCulloughs Bridge (Tahuian).

Type in Finlay collection.

Differs from *C. rudis* in fewer and more knobby nodules and shorter canal.

Cordieria huttoni n. sp. (Figs. 52, 53, 54, 55).

Shell small, rather slender. Embryo worn. Spire subequal in height to aperture, outlines straight, angle about 30 degrees. Whorls angled at upper third, straight above and below. Suture lightly impressed, faintly wavy, submargined by a narrow cord below. Ten axials per whorl, hardly swollen on periphery (interstices narrower on spire whorls, subequal on body whorl), weak on shoulder and not reaching sutural cord, strong on body whorl to just below top of aperture, thence suddenly vanishing, this point being marked by a second but very weak blunt angulation. Whole surface with narrow rather distant spiral cords (interstices 2-3 times their width); four below shoulder on spire whorls, upper 3 stronger and more distant there and on periphery of body whorl, somewhat irregular on remainder of whorl; hardly any swelling at suture; three cords on shoulder, lower two very weak and faint, uppermost thus rendered prominent, though not stronger than peripheral cords and not really margining suture. Aperture narrowly pyriform, canal short, pillar and sinus as in *C. haasti*. The type has only one sloping, medial, rather weak plait on the pillar; the sole paratype shows some indication of an extremely weak and distant second plait, almost at top of the pillar.

Height, 8.5 mm.; of aperture, 4 mm.; width, 3 mm.

Locality — Upper Waihao greensands, McCulloughs Bridge (Tahuian).

Type in Finlay collection.

Of more slender habit than the other three species, having fine spiral cords with wide interstices instead of their coarse spirals and sublinear grooves. Very characteristic is the presence of but one distinct plait, much lower down on the pillar than in its congeners.

The Geology of the North-west Portion of Manukau County, Auckland.

By C. W. FIRTH, M.Sc., Auckland University College.

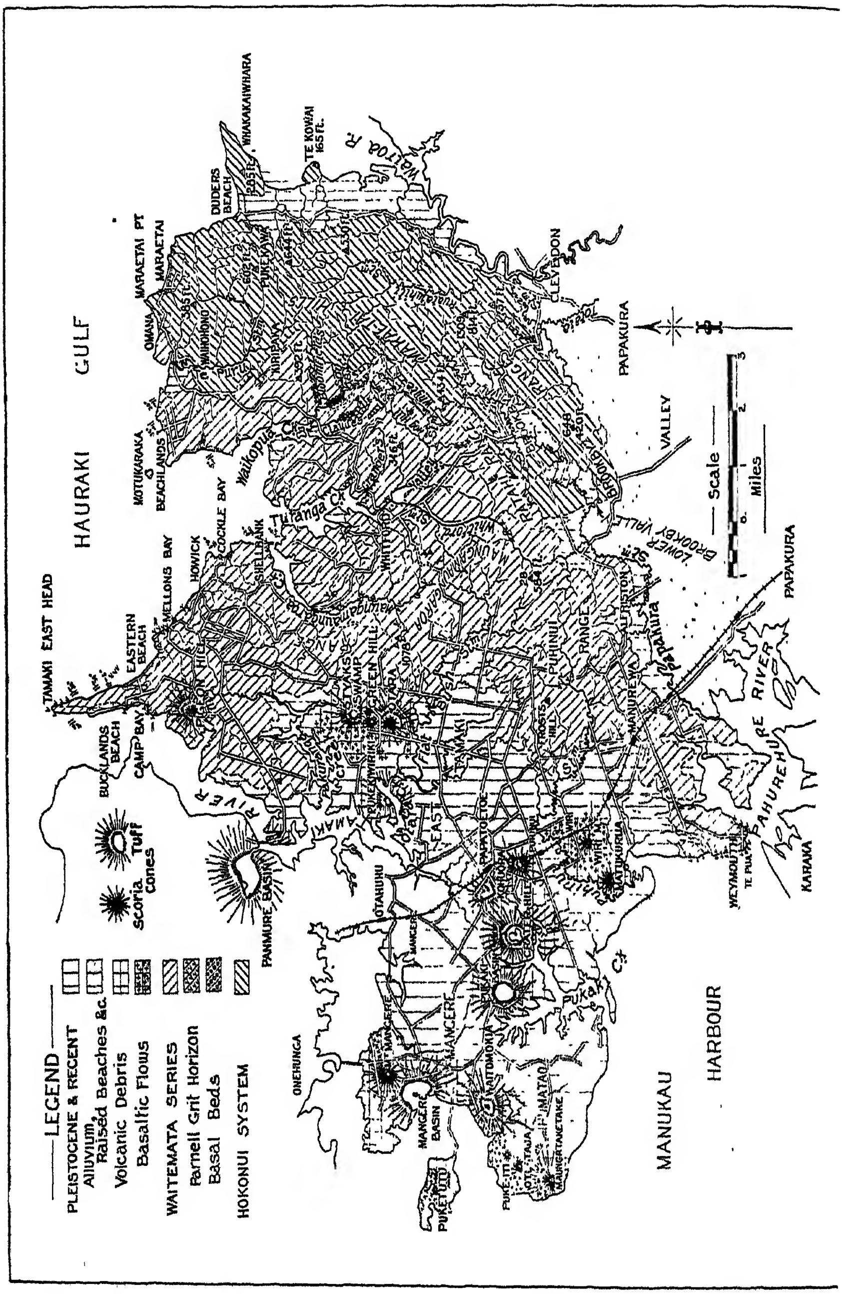
[*Read before New Zealand Science Congress on Jan. 29th, 1929; received by Editor, 3rd January, 1930; issued separately, 29th May, 1930.*]

PLATES 7–23.

CONTENTS.

INTRODUCTION.

THE district dealt with in the present paper comprises a clearly defined area of approximately 130 square miles lying between Tamaki River, 7 miles south-east of Auckland City, and Papakura Valley a further 11 miles south-east. On its northern limits it is bounded by the eastern shore-line of Hauraki Gulf and on its western by Manu-


LEGEND
PLEISTOCENE & RECENT
Alluvium, Raised Beaches &c.
Volcanic Debris
Basaltic Flows
WAITEMATA SERIES
Parnell Grit Horizon
Basal Beds
HOKONUI SYSTEM
Scoria
Tuff
Cones
HAURAKI GULF
MANUKAU HARBOUR
Scale
Miles
TAMAKI EAST HEAD
BUCKLANDS BEACH
EASTERN BEACH
MELLONS BAY
HOWICK
COCKLE BAY
SHELLBANK
BEACHLANDS
MOTUKARAKA
OMANA
MARAETAI
MARAETAI PT.
DUDERS BEACH
WHAKAKAIWHARA
TE KOWAI 165 FT.
CLEVEDON
PAPAKURA
VALLEY
LOWER BROOKBY VALLEY
PANMURE BASIN
ONEHUNGA
OTAHUHU
MANGERE
PAPATOETOE
EAST TAMAKI
GREEN HILL
PUHINUI
RANGE
MANUREWA
WEYMOUTH
KARAKA
PAHUREHURE RIVER
PUKETUTU

kau Harbour. Papakura Valley is a marked tectonic depression crossing the Auckland Isthmus from Manukau Harbour near Papakura Township, to Hauraki Gulf in the vicinity of Clevedon, and therefore invests the district with a degree of structural as well as geographical unity.

The area studied consists essentially of three distinct major topographical units, which rise successively from west to east in the form of huge steps, which are bounded by prominent structural features and possess the characters of earth-blocks. The most easterly and highest of these units is composed essentially of comparatively resistant Mesozoic rock, and comprises the rugged, largely bush-clad Maraetai Hills; the central one is characterised by softer Tertiary sandstone, and displays a more subdued topography, whilst the western and lowest comprises extensive plain-like lowlands of unconsolidated Pleistocene silts bordering Tamaki River and Manukau Harbour.

The investigation was carried out in 1928 in fulfilment of the requirements of the Master's degree under the supervision of Professor J. A. Bartrum, to whom the writer's thanks are due.

PREVIOUS WORK.

As early as 1853 Hochstetter (1864)* examined the volcanic centres and underlying Pleistocene sediments of the western portion of the district, whilst in 1860 Heaphy published notes upon the adjoining volcanoes of Auckland. Apart from this, and the recent work of Bartrum (1927) relating to certain structural features of its eastern margin and to the pumiceous silts bordering Lower Wairoa River, all other geological investigation prior to that here recorded has been confined to the coastal section from Tamaki River to Waikopua Creek, and deals mainly with the controversial subject of the age of certain volcanic grits of the Waitemata Series. The published views of Hutton (1871), Cox (1882), Park (1886; 1889), McKay (1888) and Fox (1902) on this question will be summarised in a later section of this paper. A list of the fossils recorded from the fossiliferous horizons of the Waitemata Series is given by Clarke (1905), and includes specimens collected from the coastal section mentioned.

In an attempt accurately to revise the somewhat misleading geological maps already published and compiled from work of the localised nature indicated above, the writer has made a detailed study of the whole district, and has obtained sufficient data not only to describe its stratigraphy, but also to break virgin ground by discussion of its post-Mesozoic geological history and its physiographic development during post-Tertiary times. It has furthermore been possible to map, as accurately as the scale used would permit, the drainage and other topographic features of the district, and thus amplify the very inadequate information given in earlier physiographic maps.

*See list of literature cited for full reference.

Resumé of Stratigraphy.

The oldest rocks of the district are disordered greywackes, assigned by recent writers to the Hokonui system of Trias-Jura age, which are developed almost exclusively in the Maraetai hills and the hills bordering the Brookby valleys. These rocks are followed westward by beds of the Waitemata Series (? Miocene), the several members of which form an unbroken sequence from basal limestones, developed at Waikopua Creek, to heavy-bedded sandstones with intercalated tufaceous green sandstones and volcanic grits of the so-called Parnell Grit horizon, such as are perfectly exposed along the shores of Waitemata Harbour and the adjacent shores of Hauraki Gulf. The contact of this "youngermass" with the Trias-Jura "oldermass" in all cases is highly unconformable.

The absence of such beds as the "hydraulic limestone" (Onerahi Series) of probable Upper Cretaceous age, which Bartrum (1924) believes to underlie unconformably the beds of the Waitemata Series in Riverhead-Silverdale district, 20 miles north, and of the coal measures forming the base of the Tertiary sequence in Hunua district, 8 miles south, would suggest that the full post-Hokonui succession is not developed in the present area. It is possible, though not demonstrable, that post-Hokonui beds older than those actually exposed may exist under the area, buried beneath overlapping younger beds.

Fluviatile and estuarine deposits, probably of Pleistocene age, have an extensive development in the plain-like lowlands bordering Tamaki River and Manukau Harbour known throughout this paper as the "coastal lowlands." They rest unconformably on Tertiary sandstone in places along the Hauraki Coast, and on Trias-Jura greywacke adjacent to Lower Wairoa River. The youngest deposits of the area are represented by raised beaches at numerous places along the coasts, and by volcanic tuff and scoria cones, with associated basaltic flows, which rest on the Pleistocene silts of the coastal lowlands.

Resumé of Topography and Structure.

As already suggested in the Introduction, three distinct major topographical and geographical units are defined by stratigraphical and structural considerations in the present district. (See Text Fig. 1).

The most westerly unit comprises the coastal lowlands, which cover some 50 square miles, and present a plain-like surface, rarely over 60 ft. above sea-level, the monotony of which is relieved by somewhat numerous small scoria cones and tuff craters. The topography of this plain is clearly due to two cycles, for the lower reaches especially of the streams which drain across the plain to the west, display clear evidence of rejuvenation in that they are sharply entrenched, to a maximum depth of 15 ft., below the very broadly convex late-mature forms of an earlier cycle. (See Fig. 29). Some of the larger streams, especially those tributary to Otara and Pakuranga creeks, which spread fan-wise across the lowlands of East

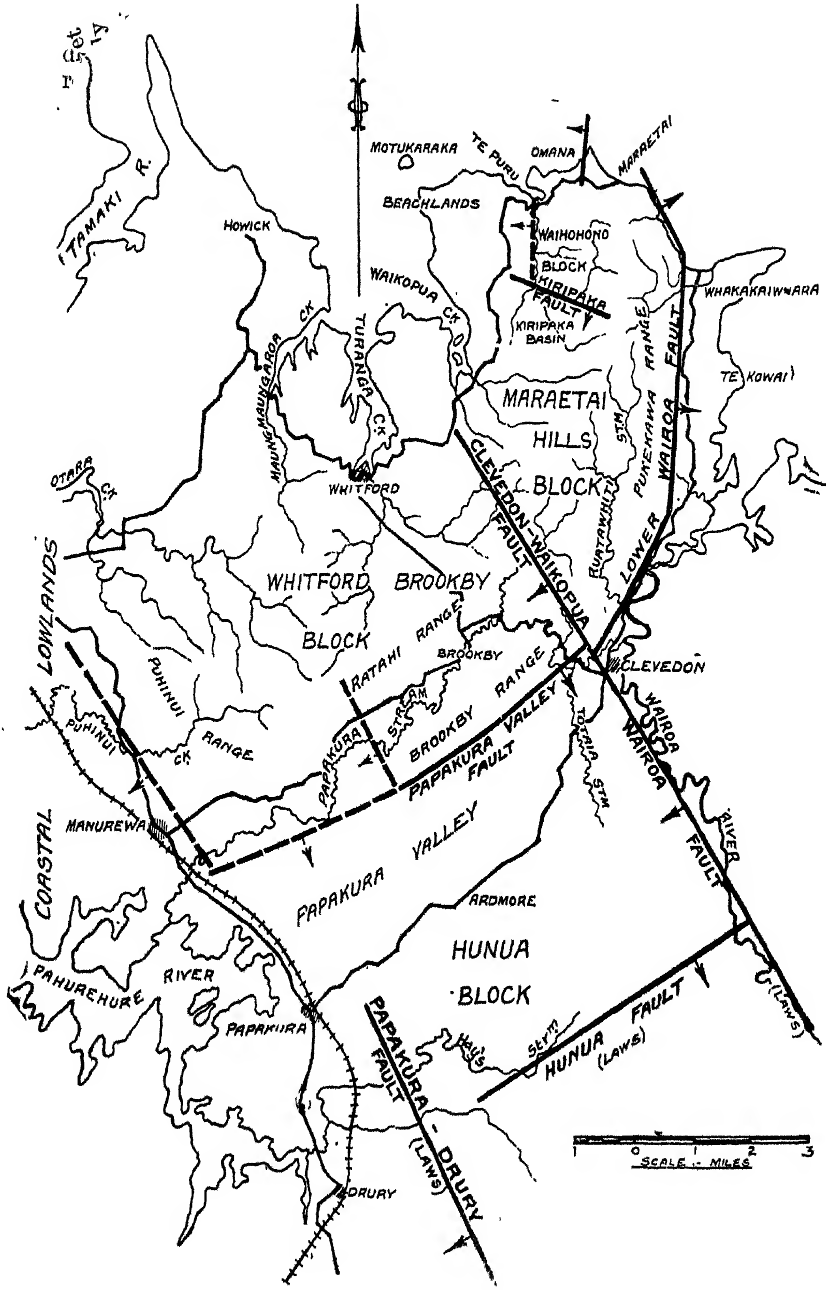


FIG. 1.—Index-map of faults in North-West Manukau and the neighbouring Papakura-Hunua District.

Tamaki district from Tamaki River to the fringing hills of Tertiary sandstone further east, have built small sharply-defined flood-plains during the second cycle, but many smaller streams have not y adjusted themselves to the new base-level, and still flow in sharpı entrenched meanders. Recent comparatively small uplift is undoubtedly partly responsible for the institution of the rejuvenation evidenced, but it is probable that deforestation of this formerly entirely bush-clad locality has been at least as potent as uplift in producing this feature.

On their eastern margin the coastal lowlands abut against abruptly-rising hills of Tertiary sandstones, which characterise the central topographic unit—hereafter called Whitford-Brookby Block—and run in a broad arc, concave to the west, from the vicinity of Howick to Manurewa township. These hills, comprising Maungamaungaroa and Puhinui ranges, rise to an elevation of 580 ft. near Alfriston, but descend gradually eastward to the low-lying Whitford and Brookby valleys. In Ratahi and Brookby ranges, which border the latter valleys, harder mid-Mesozoic greywackes replace the Tertiary sandstone with expectable changes in topography. Tertiary beds form another prominent feature in a long gently-sloping surface which gradually descends from the flanks of the lofty Maraetai hills—the mass of greywacke which constitutes the third or eastern topographical unit of the district—to an almost level area of Pleistocene deposits, about 60 ft. above sea-level, at Beachlands.

As a general rule, the Tertiary sandstone terrain presents readily recognisable features. In major detail it invariably displays comparatively coarse-textured topography, which is often accompanied by distinct stepping as a result of slight variations of hardness in the sub-horizontal strata, and by mammillary contours due to large-scale slips with sharp scarps at their upper margins, at times prominent near the crests of divides.

In contrast with such characteristics, the maturely dissected greywacke terrain invariably exhibits close-textured insequent drainage developed as a result of its remarkably uniform lithological nature and its heavy cover of impervious residual clay.

Identification of the various geographic units does not depend, however, solely on details of minor topography, but is simplified by the fact that the area described consists of two very distinct earth-blocks, differentially uplifted with respect to each other and to the neighbouring tectonic depression of Papakura Valley. The higher eastern Maraetai Hills Block culminates in a height of 820 ft. near Clevedon, and is bounded eastward by a steep scarp-slope which is believed to be due to a great fracture herein called Lower Wairoa Fault, as is suggested by Bartrum (1927, p. 246). The lower or Whitford-Brookby Block rises to a maximum height of only 580 ft., and is separated from Maraetai Hills Block north-east of it by a prominent scarp, developed by what is here designated the Clevedon-Waikopua Fault. On the south-east it descends abruptly by the scarp of Papakura Valley Fault (Laws, MS.) to the Papakura Valley lowland, whilst it is possible that its south-western margin may have been determined by a north-west extension of the Papakura-Drury Fault of Laws (*loc. cit.*). (See Text-Fig. 1).

All these fractures will be considered in detail later. For the present it will suffice to state that their average orientation in two directions—north-east to south-west and north-west to south-east respectively—is in close agreement with that of the major fractures responsible for the blocking out of the whole Hauraki area, in common with other parts of Auckland Province north of the Rotorua-Taupo volcanic zone (Henderson, 1924 a). Structurally, therefore, it is apparent that the district is in keeping with the generalisation of Cotton (1916, p. 319) that New Zealand as a whole may be regarded as a "concourse of earth-blocks of varying size and shape."

COASTAL FEATURES.

The coastal topography displayed on the coasts both of Hauraki Gulf and of Manukau Harbour is essentially that of a comparatively recently submerged area of low relief, modified subsequently by erosion to give the approximately stable coastal outlines of the present day.

It is apparent that, following submergence, extensive cliffing took place even along the shores of long and narrow drowned valleys, formed by this movement, which are represented at the present time by Tamaki River, Maungamaungaroa, Turanga and Waikopua creeks on the Hauraki Gulf coast, and by Pukaki, Puhinui and Pahurehure creeks of Manukau Harbour. This cliffing has, however, long ceased except at certain points in the creeks of the Manukau coast, and has been followed by the gradual infilling of bay-heads by débris derived by stream and wave erosion, so that at the present time prominent abandoned sea-cliffs are general with extensive mud-flats seaward of them.

Progradation of the shore-line has advanced still further in some cases. For example, the mouth of Maungamaungaroa Creek is partly closed by a prominent recurved shell spit marking the zone of conflict of the currents in this creek with those of the nearby main channel of Turanga Creek, whilst low barrier beaches enclosing swampy flats are common in the wide open mouths of Turanga and Waikopua creeks. Similar conditions hold near the mouth of the Wairoa River, where deltaic deposits constantly reduce the slope of the off-shore profile, and thus produce the requisite conditions for progradation by a series of barrier beaches, as is admirably shown by the infilling of the formerly deep embayment between the greywacke residuals, Whakaiwhara and Te Kowai, of this locality. (See Fig. 5).

Simultaneously with progradation in the drowned valleys, the intervening exposed portions of the initial coasts have suffered very extensive retrogradation. In the sandstone terrain from Tamaki River to Omana Beach this has resulted in the development of even lines of sheer cliffs, fronted everywhere by extensive wave-cut platforms (Fig. 6). These cliffs attain a height of 80 ft. near Howick, whilst the shore-platform near Beachlands extends well beyond Motukaraka, a large, flat-topped, cliff-encircled stack which lies half a mile off-shore from the mainland. The results of selective erosion along the lines of cliffs are clearly demonstrated in the not unusual definite association of pocket beaches with zones of marked contortion of the sandstone

strata, and in the cutting of small sea-caves along fault-lines or in the weaker members of highly tilted strata. The greywacke terrain east of Omana displays a much less advanced stage of shore development, and is characterised by a series of deep crescentic bays and steep beaches, separated by comparatively subdued headlands which are continued seaward as jagged reefs.

Well-defined remnants of raised beaches backed by abandoned sea-cliffs form a constant feature of all sheltered sections of the coasts of the district, and clearly demonstrate a small relative uplift in recent times. Evidence of this is particularly clear in the comparatively immature coast of the greywacke terrain, where elevated wave-cut benches are also preserved on certain of the headlands, and corroborate the evidence of the raised beaches at the heads of the bays (See Fig. 7). Further details of these will be given when dealing with post-Tertiary history.

Manukau Harbour presents several special features in its coasts. Consequent on the rapid erosion by waves of the soft Pleistocene beds of the plain-like, low-lying area by which it is bordered, this harbour at the present time is little more than a series of mud-flats, whilst its shore-line has been greatly simplified. Minor details of the coast are now determined by the relative proximity, one to another, of the channels crossing the mud-flats. Thus the original trench-like valleys that were drowned by submergence are still being widened by wave-erosion, and along their courses and near their mouths present lines of low, sheer, crumbling cliffs, though elsewhere, in the protection afforded by wide stretches of mud-flat, progradation by low barrier beaches has recently been instituted.

Detailed Stratigraphy.

As stated previously in the resumé of stratigraphy, three very distinct rock-groups are developed in the present district, and will now be discussed in some detail under the following headings:—

(1) Hokonui System (? Trias-Jura).
(2) Waitemata Series (? Miocene).
(3) Post-Tertiary Deposits.

(1) Hokonui System (? Trias-Jura).

Rocks referable to the Hokonui System outcrop over 30 square miles in the north-east portion of the district studied, and, as far as can be seen, are an unbroken series of fine to moderately coarse-textured greywackes of uniform character, so closely jointed as to obliterate all traces of original bedding planes, and apparently entirely unfossiliferous. Closeness of joints has so facilitated weathering that a deep cover of stiff, yellowish-white or reddish residual clay is general, with the result that outcrops of all but greatly weathered rock are confined to the more youthful stream valleys and to the coastline.

Fine-grained greywacke, in which occasional angular fragments of plagioclase and quartz are the only recognisable minerals, characterises the Maraetai Hills and predominates also in the hills

bordering the Brookby Valleys. Not uncommonly it is so closely jointed as to crumble under the hammer, but in some cases, as at Whakakaiwhara, it is rendered very hard and resistant as a result of the filling of the joints fissures with siliceous material.

Rock appreciably coarser in grain and with a much wider spacing of joints has a very limited occurrence, and appears to be restricted to the vicinity of Trig. 648, in Brookby Range, and to the summit of Ratahi Range, immediately opposite on the north-west side of Upper Brookby Valley. In the former locality it is indicated only by numerous spheroidally weathered boulders of up to 3 feet in diameter, but in the latter locality it is also seen *in situ* in an outcrop which, however, is too limited to display any evidence of structure other than jointing.

Under the microscope this rock (Fig. 35) is seen to consist of an even-grained mosaic of fragments of plagioclase—probably andesine—and orthoclase, in sub-equal amounts, with less abundant angular grains of quartz, minor augite and green hornblende and occasional grains of magnetite and zircon. Chlorite is a common alteration product, whilst the orthoclase is usually sericitised. Fragments of pre-existing andesite as much as one-eighth inch in diameter, and of a dense, fine-grained, indeterminate volcanic rock, are also moderately plentiful, together with occasional tiny pellets of fine-grained sandstone.

The only other variation from the predominating fine-grained greywacke is seen in an interesting occurrence on the eastern side of the upper valley of Te Puru Stream, where outcrops of a comparatively resistant pinkish-white quartzose vein or stratum form a series of prominent bare ridges which are roughly aligned for nearly one mile, in a direction slightly east of north. The true nature of the occurrence of this rock is obscure. In its upper levels the "reef" is predominantly quartzose, yet exhibits close jointing identical with that of nearby fine-grained greywacke. Further, in a tributary of Te Puru Stream that has cut through it to a depth of nearly 200 ft., it appears to pass down into a highly siliceous greywacke which is with difficulty differentiated from flanking dense normal greywacke. This fact suggests that the upper quartzose portions are to be regarded rather as the cap of a band of such rock cemented by silica supplied by the weathering of still higher, now-removed portions of the same band, than as a vein-filling or a metasomatic replacement of original greywacke adjacent to a fissure. If this explanation is correct, the roughly-aligned quartzose outcrops must be regarded as representing a definite sub-vertical stratum, at least 20 ft. thick, which strikes a little east of north.

Liberal coatings of manganese oxide or hydrate occur on some outcrops of dense fine-grained greywacke in the vicinity of the above "reef." The parent rock on sectioning is also found to be crossed by veinlets filled with quartz and a mineral which is probably prehnite, but which unfortunately is not sufficiently well crystallised to allow conclusive tests to be made.

By reason of their unfossiliferous nature and the elimination of all evidence as to internal structure, the Hokonui rocks of the district unfortunately throw no new light on the question of the

age or structure of the system to which they are allocated. Neither do they offer any evidence as to their origin, except that they show that the land mass from which they were derived was constituted in part of crystalline rocks.

(2) Waitemata Series (? Miocene).

Distribution and General Description.

Beds of the mid-Tertiary Waitemata Series—a term introduced by Hochstetter (1864) for "the horizontal beds of sandstone and marls which form the cliffs of the Waitemata"—lie west of the rocks of the Hokonui System on the western flanks of the Maraetai Hills and of Ratahi Range, and occupy the whole of the central portion of the district. Still further west they pass under the Pleistocene beds of the coastal lowlands facing Tamaki River and Manukau Harbour.

The normal beds of the series are alternating beds of unfossiliferous, fine-grained, yellow-brown sandstones and thin bands of fine gray mudstone. The latter are never more than a few inches thick, but invariably contain numerous fragments of wood and bark, which, however, are generically indeterminate and therefore of no value palaeontologically. Eminent cross-bedding on a fine scale is common in the sandstone members. These also show occasional gritty phases and rare, small pyritous nodules, and frequently incorporate lenses or pebbles of sandstone which apparently have resulted from contemporaneous erosion.

Thin, hard, irregularly-concretionary bands which have resulted from cementation by calcareous material are general throughout the series. A special phase of this is shown north of Buckland's Beach (Fig. 9), where numerous perfectly-rounded concretions up to 18 ins. in diameter have weathered from the adjacent cliffs. Deposition of calcareous cement around small pebbles of mudstone is indicated in broken specimens, in which fractures lined by calcite crystals are also seen to be common. This type of concretionary sandstone is the "cannon ball sandstone" of Cox (1882).

Interbedded with the normal beds of the Waitemata Series are thick strata of a volcanic grit of variable texture—the "Parnell Grit." In addition, however, there are two sets of beds which by reason of their fossiliferous nature render the present district specially important: (a) the so-called "Turanga greensand" of early writers (b) greywacke conglomerates and impure limestones which form the base of the Waitemata Series at Waikopua. These beds will be considered in some detail in the following pages.

Basal Waitemata Beds.

At distances varying from one-quarter to one-half of a mile east of Whitford-Maraetai road, in the beds of Bloomfield's Stream, South Branch, and Claude's Stream—the three largest streams draining into the head of Waikopua Creek—there are some very interesting but limited outcrops of impure limestones (Fig. 10), lime-cemented greywacke-breccias and calcareous green sandstones which

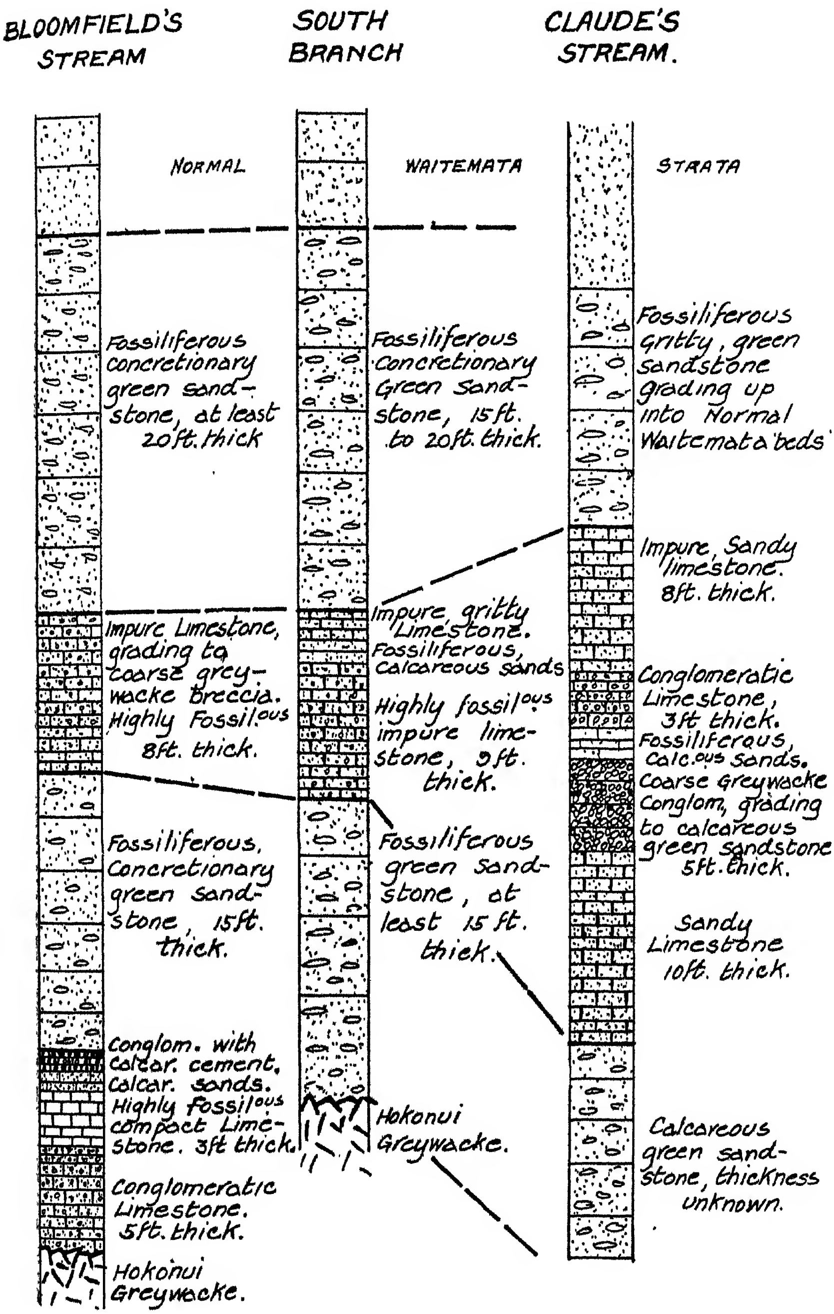


FIG. 2.—The main sequences of basal Waitemata beds exposed at Waikopua.

rest highly unconformably on Hokonui greywacke, and are followed conformably by normal beds of the Waitemata Series. These beds are the oldest exposed members of the "youngermass" in the present area, but in spite of their palaeontological and stratigraphical importance the only published account of them is a generalised description made by Park in 1886, who correlated them with the beds of the so-called Papakura Series of Hutton (1871, p. 246), developed at Hay's Creek, Papakura, which he showed to be the basal members of the Waitemata Series.

Considerable variation in facies occurs in the several outcrops at Waikopua, but nevertheless certain strata appear to be sufficiently constant throughout the main outcrops to suggest the following general succession, which varies in some respects from that given by Park:—

6. Normal Waitemata beds
5. Concretionary green sandstone
4. Impure limestone; coarse greywacke conglomerate
3. Concretionary green sandstone
2. Conglomeratic limestone
1. Hokonui greywacke.

The complete sequences exposed in the several streams are given in Text-Fig. 2. So far as is known that at Claude's Stream has not been previously recorded or described.

The main or downstream outcrops in all three streams display strata with a constant dip to the north-west of from 5° to 8°, which brings successively lower beds of the sequence into view for approximately 10 chains. They end abruptly against steep, narrow ridges of greywacke, upstream of which are further more circumscribed outcrops which occupy pockets between similar greywacke barriers. The only connection between the beds of the main outcrops and these upstream outcrops lies in the fact that both are followed conformably by normal Waitemata beds which over-ride the intervening barriers of greywacke. The "basal" beds exposed in the upstream outcrop at Bloomfield's Stream are coarse, poorly-cemented conglomerates which grade upstream into gritty, impure limestone. Of two similar outcrops at South Branch, one shows a limited occurrence of gritty green sandstone and the other, 5 chains upstream from the first, a prominent band of limestone which is exceptionally pure in places and consists almost entirely of an open-textured mass of polyzoa, foraminifera, algae, brachiopods and echinoid fragments; above the limestone there is about 40 ft. of green sandstone. At Claude's Stream the only "upstream" representative is a band of poorly-cemented, roughly-sorted greywacke breccia, at least 8 ft. thick, which coarsens upstream until included fragments as much as 9 in. in diameter are common.

The green sandstone members of these basal beds are generally fine-grained and contain sporadic small greywacke pebbles. The limestones are much coarser in texture, exhibit cross-bedding on both fine and coarse scales, and thin out laterally in the form of lenses. Evidence of minor faulting or down-sagging at or adjacent to steep contacts with the greywacke of the "oldermass" is complete in

FIG. 5.—Typical bay-filling between Whakakaiwhara and Te Kowai (right centre). The barrier-beach behind which this filling has taken place is clearly seen on its seaward margin. Remnants of an earlier barrier-beach are still preserved immediately to the right of this view.

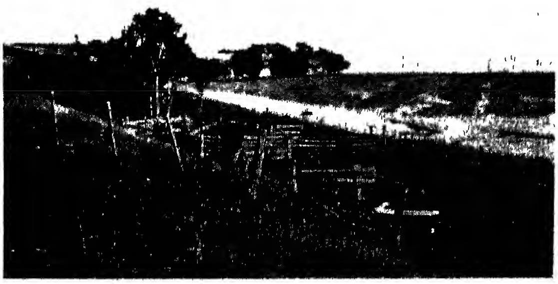


FIG. 6.—Typical wave-cut platform and cliffs (in distance) of the Waitemata sandstone terrain, western portion of Omana Beach. The well-defined terrace behind the present storm beach (foreground) is a characteristic raised beach.

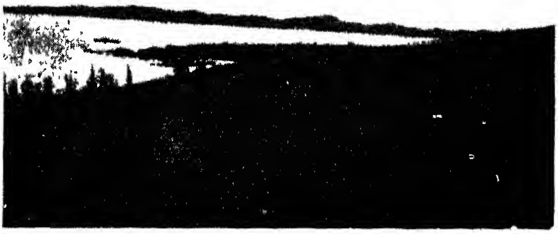


FIG. 7.—Uplifted shore-platform 8 ft. to 10 ft. above high-water mark cut in greywacke at the promontory between Omana and Maraetai Beaches.

FIG. 8.—Typical raised beach deposits resting on a wave-planed surface of Pleistocene clays; eastern portion of Omana Beach.
[*Photo., J. A. Bartrum.*

FIG. 9.—Concretions eroded from "cannon-ball" sandstone on the wave-cut platform north of Buckland's Beach.

FIG. 10.—Impure limestone conformably overlying green sandstone; main outcrop, South Branch, Waikopua.

FIG. 11.—Anticline in Waitemata strata of sea-cliffs between Tamaki East Head and Eastern Beach.

FIG. 12.—Thrust-fault in Waitemata strata between Eastern Beach and Mellon's Beach.

Fig. 13.—Conformable relations of Parnell Grit (shore-platform and base of cliffs) and horizontal sandstones and mudstones of Waitemata Series west of Mellon's Beach.

Fig. 14.—Typical Parnell Grit at the north end of Camp Bay. Tufaceous sandstone shows above the Grit at the top of the cliff.

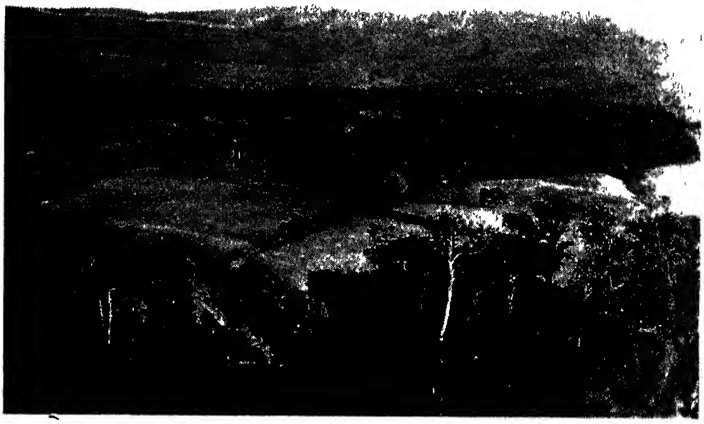


FIG. 15.—Kiripaka Basin from the hills above Kiripaka scarp, looking south across the denuded greywacke floor to Waikopua divide (middle distance) and the main range of Maraetai Hills beyond.

[Photo., R. W. Firth.

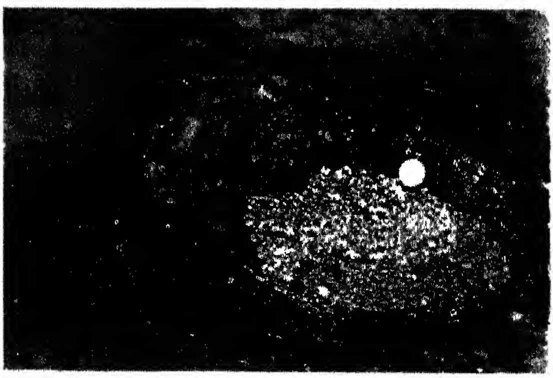


FIG. 16.—Fossil pothole in Waitemata sandstone at base of Pleistocene beds in bay east of Beachlands Wharf.

[Photo., J. A. Bartrum.

FIG. 17.—Material of the "30 ft. to 35 ft." terrace at road from Clevedon to Duder's Beach. Grey muds at the base followed by greywacke conglomerate and then light-coloured pumiceous silts.

FIG. 18.—Normal fault intersecting Waitemata and Pleistocene strata near Beachlands Wharf.

[Photo., J. A. Bartrum.

Fig. 19.—Main crater, Mount Mangere; a small scoria-cone rises from its floor with a tiny shallow crater at its left (west) margin and another (invisible) on the right. There is a smaller, deep crater in breached rim of main cone, near the middle group of trees.

Fig. 20.—Mangere Basin, viewed from Mount Mangere, with small scoria-cone as the central island. Maungataketake (A) and Otuataua (B) volcanoes in distance on right.

Fig. 21.—Scoria-cones on floor of crater of tuff-cone of Waitomokia. Otuataua rises above tuff-ring in distance on left.

Fig. 22.—Otuataua (Quarry Hill) from the south.

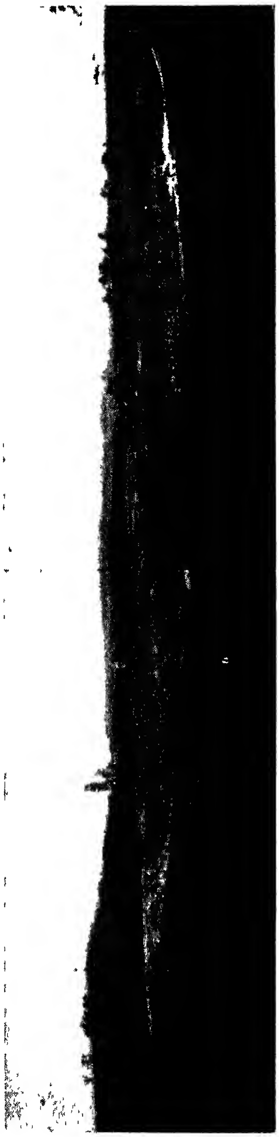


Fig. 23.—Pukaki Basin from the west. Its caldera is occupied by a marine swamp with its outlet in distance to the right of centre.

Fig. 24.—Panorama of Crater Hill, Papatoetoe, from north-east portion of encircling tuff-cone. Swamp-filled sink in lava floor of crater at centre, with scoria-cone to left of it.

FIG. 25.—Overlooking breached eastern lip of crater of Otara to scoria mounds beyond. Part of tuff-ring behind the mounds, and Tertiary sandstone hills of Maungamaungaroa Range in the distance.

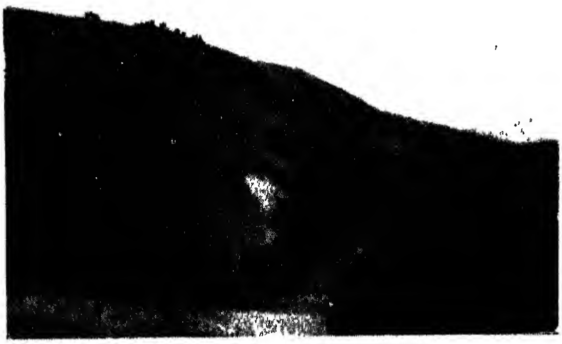


FIG. 26.—Part of scarp of Clevedon-Waikopua Fault. A small tributary of Hog Hill Stream at base of scarp is working headwards in Waitemata sandstone rendering the capture of Whyte's Creek imminent.

FIG. 27.—View looking south-east along middle section of scarp of Clevedon-Waikopua Fault.

FIG. 28.—Looking north-west near Clevedon along line of Clevedon-Waikopua Fault. Transverse scarp of Lower Wairoa Fault on right half, that of Papakura Valley Fault off-set to north-west on left half. Filling of fault-angle-depression of Papakura Valley in foreground.

Fig. 29.—Shallowly entrenched meanders of a tributary of Tamaki River near Papatoetoe.

Fig. 30.—Conical hill at debouchure of Papakura Stream (on left) from Maraetai Hills Block on to Upper Brookby Valley (distance). Small stream on right beheaded at middle distance by recession of scarp of Clevedon-Waikopua Fault.

FIG. 31.—Back-slope (distance) of tilted Hunua Range Block viewed from north-west across alluvium-filled fault-angle-depression of Papakura Valley (middle distance). Dissected scarp of Papakura Valley Fault in foreground.

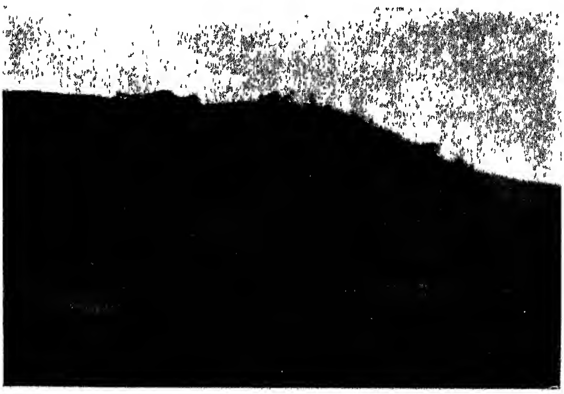


FIG. 32.—Spur-facets of middle section of scarp of Kiripaka Fault. Photographed from distance of 300 yards with 4½ in. lens.

Fig. 33.—Low scarp exposed by waves at faulted contact of Pleistocene beds (shore-platform in foreground) with greywacke (in scarp) at east end of Omana Beach. Elevated beach-deposits rest on wave-planed surface of greywacke.

[*Photo., R. W. Firth.*

Fig. 34.—Terraces at mouth of Te Puru Stream. Waihohonu Block is visible in far background.

[*Photo., R. W. Firth.*

FIG. 35.—Coarse-grained greywacke from Trig. Station 648, Brookby Range. Ordinary light; magnification 46 diams. Quartz is sparse and weathered feldspar abundant. Grains of hornblende (h) and augite (a) are visible.

[*Photomicrograph by J. A. Bartrum.*

FIG. 36.—Section of typical Tertiary limestone from Waikopua, with abundant foraminiferal, polyzoan and algal remains. Magnification, 10 diams.

[*Photomicrograph by J. A. Bartrum.*

FIG. 37.—Coarse-grained basic olivine basalt, Green Hill Quarry. Large idiomorphic phenocrysts of olivine appear in groundmass of augite, plagioclase and magnetite. Ordinary light; magnification, 46 diams.

[*Photomicrograph by J. A. Bartrum.*

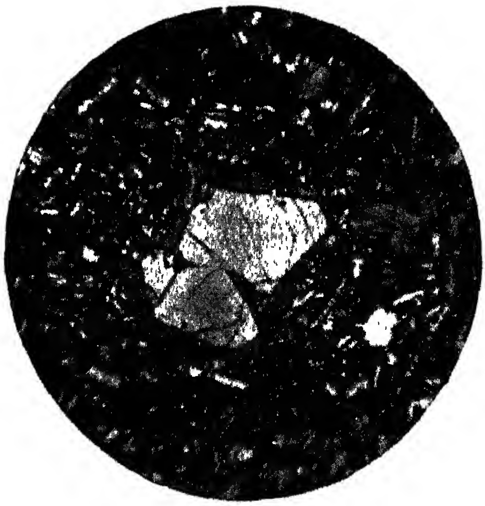


FIG. 38.—Fine-grained highly basic basalt from small flow on west side of Maungataketake. Note the cluster of crystals of augite around the central phenocryst of olivine. Ordinary light; magnification, 46 diams.

[*Photomicrograph by J. A. Bartrum.*

several cases, but is explicable merely by the shrinkage on consolidation and drying of a moderate thickness of beds.

The nature of the basal deposits described above suggests that the beds of the main outcrops were deposited in open water offshore from a rugged, youthful coastline, in a regular succession that suggests certain fluctuations of the strandline but the maintenance of moderately shallow-water and locally-sheltered conditions for some time prior to the deposition of the rapidly-accumulated sands and muds that characterize the main mass of the Waitemata Series. Highly-variable conditions of deposition must have held in embayments of this youthful coastline, in which the effects of minor fluctuations of the strand would be much less apparent than in open water; such fluctuations would give rise to the beds of the "upstream" outcrops and account for the lack of connection between these and the succession of the main outcrops.

The palaeontology of these beds at Waikopua is as yet imperfectly known. The limestones are highly fossiliferous (Fig. 36), but unfortunately much of the material is fragmentary. Polyzoa, foraminifera, and algae (? *Lithothamnion*) abound, whilst fragments of lamellibranchs, echinoids, gasteropods, and brachiopods, and occasionally shark teeth, are plentiful. Portions of the shells of *Ostrea* are common in some coarse conglomerates. In the green sandstones foraminifera are particularly abundant, with less frequent, perfectly preserved brachiopods (*Hemithyris antipoda*), small Pectens (*P. fischeri; P. polymorphoides; Amussium zitteli*) and small gasteropods.

Through the kindness of Mr. W. J. Parr, of Caulfield, Australia, who most generously undertook the identification of the foraminiferal fauna both of limestone and green sandstone from Waikopua, the writer is able to supply lists of the foraminifera of these beds and thus bring this section of the palaeontology up to date. Mr. Parr also examined samples of the Turanga greensand and Parnell Grit facies. His determinations are tabulated at the conclusion of this paper.

Volcanic Tuff and Grit Beds of the Waitemata Series.

Introduction.

The occurrence of beds of volcanic nature interstratified with normal sandstones and mudstones has been known to be characteristic of the Waitemata Series since the time of Hochstetter (1864). The work of Hutton (1871), Cox (1882), McKay (1884; 1888), Park (1886), Mulgan (1902), Fox (1902) and Turner and Bartrum (1929) has shown these pyroclastic beds to outcrop abundantly over a distance of 30 miles from Waiwera, 20 miles north of Auckland City, to Turanga Creek in the present area, and also throughout the Auckland Isthmus.

Apart from the so-called "Orakei greensand," these volcanic beds north and west of Howick vary from fine volcanic tuffs and grits—the normal facies—to coarse volcanic breccias and conglomerates, and are described collectively under the name "Parnell Grit." East of Howick, however, the Parnell Grit is replaced by

much finer, but nevertheless still definitely tufaceous, highly fossiliferous beds which, under the term "Turanga greensands," have been correlated by earlier writers with the "Orakei greensand." In frequent association with the Turanga greensand, though by no means so obviously tufaceous or fossiliferous, are fine-grained, often thinly-bedded yellow-green or brownish-yellow sandstones to which, for convenience in description, the term " tufaceous sandstone " is here applied. These appear to be intermediate between the more definitely volcanic beds and normal Waitemata sandstone.

In addition to the Parnell Grit previously recorded on the Hauraki Gulf Coast of the present district between Eastern Beach and Mellon's Bay, and to a narrow band only 2 ft. thick, which dips across the face of the cliffs a few chains north of Cockle Bay, several outcrops of it also occur at Buckland's Peninsula.. This peninsula is occupied by a sharp anticline, the axis of which trends north-north-west, parallel to the coast, and has a constant plunge to the north (Fig. 11). Outcrops of the "Grit" occur on both sides of the peninsula, namely in an extensive reef one-quarter of a mile off-shore from Eastern Beach, in the cliffs at both ends of Camp Bay, Tamaki River, where a gradual transition from grit to normal sandstone through tufaceous sandstone is suggested, and in four outcrops, developed from repetitions of the same bed by normal faulting, near its extremity.

The same type of rock also outcrops at several places in Maungamaungaroa and Puhinui Ranges, and in the coastal lowlands occurs extensively at Weymouth, on Manukau Harbour, and also in the bed of Flat Bush Stream in East Tamaki district. In the vicinity of Papatoetoe it has been recorded in well borings 100 ft. below sea level, whilst lumps of it up to 1 ft. in diameter are found incorporated in Recent volcanic tuffs in Crater Hill.

General Description of the Parnell Grit.

Most earlier writers have agreed that the Parnell Grit everywhere shows certain distinctive characteristics, and that the facies of different outcrops differ one from another mainly in texture. The normal grit consists of angular or roughly rounded fragments of volcanic material, Waitemata sandstone, and a "peculiar, black, carbonaceous shale," generally from ¼ in. to ½ in. in diameter, welded together by finer particles of similar material cemented by calcite. In the rare cases in which the volcanic material is determinable it has been found to be an augite andesite. Lumps of such rock up to 4 in. in diameter are common in an outcrop of the Grit at Weymouth, on Manukau Harbour. Worn crystals of augite and plagioclase abound at the base of the outcrop near Camp Bay, Tamaki River.

Broken fragments of polyzoa, small Pectens and other lamellibranchs, corals and echinoderms are general throughout the Grit but are usually indeterminable specifically. Foraminifera are occasionally well preserved, but have not yet been satisfactorily worked up.

The normal occurrence of the Parnell Grit in the Waitemata beds appears to be in the nature of large lenticular masses, from 15 ft. to 25 ft. thick, probably the result of false-bedding on a large scale. In those cases where bedding is at all clearly shown the Grit itself is also false-bedded, and often incorporates near its base lenses of sandstone or aggregations of lumps of sandstone which demonstrate that variations in deposition and contemporaneous erosion have occurred.

In spite of the fact that intense deformation of normal Waitemata beds associated with the Parnell Grit is almost general, and that many of the visible contacts are faulted ones, there are enough clear sequences in the present district to show that no unconformity exists between the two sets of strata (See Fig. 13).

When exposed to sub-aerial weathering agencies the Grit readily disintegrates into small fragments and generally displays spheroidal weathering, initiated by the narrow, rather widely spaced and irregular joints which characterise the rock (Fig. 14). The major joints are frequently filled with calcite, which stands out prominently on exposed faces.

General Description of the Turanga Greensand.

Beds described by earlier writers under the name Turanga Greeensand have been recorded by them from only two localities:—(1) Near the mouth of Maungamaungaroa Creek (2) Turanga Creek, near Whitford. These beds are typically moderately fine-grained, deep-green sandstones which generally occur in thick beds with a maximum thickness of 30 ft., but otherwise exhibit the jointing, concretionary structure, and type of weathering on exposed faces characteristic of the Parnell Grit. They are definitely tufaceous but to a highly variable degree, and are usually richly fossiliferous. Polyzoa, foraminifera (see Appendix) and small Pectens are abundant, especially in the coarser, more tufaceous beds, and even the finer more sandy phases contain plentiful foraminifera and broken shell fragments.

Under the microscope the more tufaceous beds are seen to contain small but readily recognisable crystals or fragments of hypersthene, augite, plagioclase and green hornblende, with occasional glauconite and a few minute flakes of biotite. Small pebbles of greywacke are general in all beds of Turanga greensand facies.

The investigations of the writer have shown beds of Turanga greensand facies to have a much wider distribution than hitherto recorded, for they outcrop frequently in Maungamaungaroa Range in the valley of Maungamaungaroa Creek, Whitford Stream and Flat Bush Stream, and also in many places along Turanga Creek. These outcrops are far too numerous to describe fully, but from the fact that beds intermediate in character between the two types, "Parnell Grit" and "Turanga Greensand," are common, and that in many cases gradation from one type to the other, or to tufaceous sandstone, is complete, it appears that the greensand is but a finer phase

of the grit, and that the separation of the two as distinct horizons, as held by earlier writers working on the coastal sections only, is untenable.

Brief descriptions of a few of the more important and characteristic outcrops will suffice to illustrate this point. Structurally Maungamaungaroa Range appears to be a moderately sharp anticline, with its axis plunging north-north-west, which is probably a continuation of that of Buckland's Peninsula. This fact, with due consideration for the characteristic sharp local dislocations so common in Waitemata strata, explains the disposition of the numerous outcrops of the hinterland.

At an elevation of 200 ft. near Trig. 1078, a clear section shows very coarse Parnell Grit grading rapidly upwards into beds of Turanga greensand type. Nearby, at an altitude of 400 ft. determined by local distortion of the strata, similar grit grades through fine-bedded tufaceous sandstone into normal Waitemata strata.

Another perfect sequence is displayed in the headwaters of Whitford Stream one-quarter of a mile west of the crest of Whitford—East Tamaki road, where a 25 ft. face shows a thin stratum of coarse grit grading upwards through Turanga greensand to tufaceous sandstone. It may be of interest to mention that highly fossiliferous bands in the Turanga Greensand here contain numerous thick-domed *Amphistegina* up to ⅛ in. in diameter.

Again at Weymouth, the conditions of occurrence of coarse Parnell Grit, beds of Turanga Greensand facies, and tufaceous sandstone grading into normal sandstone, are such as to suggest that all belong to the one horizon. This important outcrop will be dealt with more fully later.

Origin and Relationship of the Volcanic Tuff and Grit Beds.

The chief characteristics of the pyroclastic beds under consideration are, in the writer's opinion, fully explained by the theory put forward by Turner and Bartrum (1929) that they incorporate material ejected from a series of small andesite vents connected with a common magmatic source, and deposited by currents in the form of lenses throughout a thickness of strata so small in comparison with the 1200 ft. thickness to which the Waitemata Series is known to attain in the Kaipara District, as to constitute a fairly definite horizon —the Parnell Grit horizon. The known rapid and irregular variation of these beds in texture and thickness does not appear reasonably explicable on the assumption of a single centre of eruption.

Much has already been written on the question of the relative positions of the Parnell Grit and the Turanga Greensand. The latter, it will be remembered, has been correlated with the Orakei Greensand, which is considered to underlie the Parnell Grit at Orakei Bay. (Cox, 1882; Turner and Bartrum, 1929).

In greatly weathered outcrops in road cuttings on the west side of Maungamaungaroa Gorge in the present district, what is apparently a limited band of Grit appears to follow coarse Turanga Greensand with the interposition of approximately 20 ft. of normal Waite-

mata beds. This is no more than what is to be expected in certain cases, if the above theory of origin holds, for differences of magnitude and duration among the several outbursts postulated could readily explain such seeming anomalies, without detracting in any way from the essential unity of the Parnell Grit horizon.

The majority of early writers regarded the eruptions that ultimately raised the Waitakerei Hills, 12 miles west of Auckland City, as being the most probable source of the greater part of the volcanic material of the Parnell Grit horizon. Although this theory has support in that augite andesite similar to that of the Grit also characterises these hills, it is discredited by the fact that the Waitakerei fragmentals are now considered either to close the Waitemata sequence or else to lie unconformably above it (Bartrum, 1924).

Fox (1902) went further than other workers and made subdivisions of the horizon, mainly on the grounds of variation in texture and thickness. He considered the Parnell Grit—using the term in a much more restricted sense than that usually accepted—to be younger than the Turanga Greensand, and to have derived its material from the Coromandel volcanic zone 30 miles east, but his petrographical evidence for this is certainly faulty. He correlated his other subdivisions with different stages in the development of the Waitakerei Hills.

Fox's conclusions affect the present area, for he groups an extensive outcrop of thick beds of tufaceous sandstone alternating with thin mudstone bands that occurs between Howick and Mellon's Bay with his "Wairau tuff." The actual relationship of this outcrop to normal Parnell Grit exposed in and west of Mellon's Bay is unfortunately obscured by faults, but similar interbedded tufaceous sandstones and mudstones are prominent not far distant at Shellbank, and there grade laterally into typical Turanga Greensand. Fox further groups a 2 ft. band of typical grit exposed near Cockle Bay with his "Tamaki tuff," mainly by reason of its thinness.

Much of the palaeontological evidence used by several earlier writers in support of their contention that the Parnell Grit and Turanga Greensand represent two distinct volcanic horizons has been discredited by a more complete understanding and general extension of the time ranges of the fossils concerned. Even at the present time, however, the palaeontology of these beds is too imperfectly known to warrant their correlation with other Tertiary horizons in New Zealand; nevertheless the list of foraminifera determined in the Turanga Greensand by Mr. Parr that is published at the end of this paper will prove a most important aid to future correlation.

It is also necessary to point out that earlier workers often placed undue reliance, when making correlations of separated beds, upon the maintenance of observed strike and dip throughout obscured portions of sections, for sharp dislocations very commonly affect the Waitemata strata of the district (See Figs. 11 and 12).

Fairly conclusive demonstration that the several rock facies comprising the Parnell Grit have resulted from outbursts not from one main source but from a series of small volcanic centres is afforded by the great variety of beds of this horizon exposed in low cliffs facing Manukau Harbour at Weymouth. The eruptive centre responsible for these particular beds must have been close at hand, for very coarse

Parnell Grit outcrops between Weymouth Wharf and Te Pua Point, and contains frequent lenses of water-worn pebbles of vesicular, highly feldspathic andesite up to 4 in. in diameter. This Grit passes up into a jumbled mass of very coarse sandstone breccia which also contains occasional pebbles of andesite. The facts suggest that the volcanic eruptions were accompanied by or caused local warpings or uplift which brought the earlier-deposited sediments into the zone of erosion either of waves or streams. It is especially clear at all events that deposition took place in waters that had perceptibly shallowed, for there is ubiquitous evidence of contemporaneous erosion, illustrated by the well-developed cross bedding and alternating lenses of gritty sandstone containing numerous strings of scoriaceous andesite and fine tufaceous sandstone, that characterise an outcrop stretching for nearly one mile from Te Pua Point in the direction of Puhinui Creek. There is also indication that the volcanic material was distributed from the south, for, as it is followed towards Puhinui Creek, this outcrop becomes progressively less tufaceous, and grades gradually into normal Waitemata sandstone.

In the vicinity of Weymouth Wharf a well-bedded series of alternating bands of Parnell Grit, normal Waitemata sandstone, highly tufaceous Turanga Greensand, and thin bedded "tufaceous sandstone," point to deposition of material from the same source under comparatively sheltered conditions, and are so obviously of one horizon as to suggest that a similar relationship holds for the disconnected outcrops of beds of tufaceous character in the northern parts of the district.

The andesite incorporated in the Grit at Weymouth consists essentially of phenocrysts of plagioclase—moderately basic labradorite, Ab_{35} An_{65}—set in a fine matrix of minute, irregularly-disposed plagioclase laths and magnetite grains. Colourless augite was apparently moderately plentiful in the original rock, but has now been largely altered to chloritic material.

Origin of the Waitemata Series.

In explanation of the general characteristics of the beds of the Waitemata Series, Turner and Bartrum (1929) suggest that they represent the deltaic deposits of a large stream or streams draining a land mass probably situated some distance north-west of the Waitemata area. That this land mass must have been of considerable extent is apparent when it is considered that even at the present time, after having suffered extensive erosion, Waitemata rocks outcrop over an area at least 70 miles long and 20 miles wide, and are known to attain a thickness of 1200 ft. in the Kaipara district.

It is apparent that the sediments were deposited in an extensive shallow sea at a rapid rate—so rapid as to produce conditions altogether unfavourable for the existence of marine life—during a period of progressive subsidence interrupted at rare intervals by minor negative movements seldom important enough to occasion more than slight contemporaneous erosion. Seasonal control of the rate of supply of the sediments under the conditions suggested fully explains the alternation of thick sandstones and minor mudstones characteristic of the series.

Prominent shore-line conglomerates of greywacke pebbles and impure limestones which constitute the base of the series and rest on the Hokonui basement at Cape Rodney, Kawau Island, Tiritiri Island, Motutapu, Motuihi, Waikopua and Hunua suggest that the shore-line of early Waitemata times extended from Cape Rodney, 40 miles north of Auckland, approximately in a direct line to Hunua Range, 20 miles south-east of Auckland.

The following events probably immediately preceded and accompanied the deposition of beds of the "youngermass" in the mid-Auckland area. The Hokonui (Trias-Jura) rocks that constitute the "oldermass" suffered extensive erosion after having been closely folded during the lower Cretaceous orogeny that brought Hokonui sedimentation to a close. In late Cretaceous times, the portion of this eroded mass lying north of the site of the present Waitemata Harbour, and perhaps part of it south of this, was submerged beneath seas of moderate depth and extensively covered by beds of the Onerahi Series. These beds suffered elevation and extensive erosion in early Tertiary times, and, if ever deposited upon the present area or districts further south, were now completely removed from them.

Renewed submergence, approximately during early Miocene times, apparently commenced first in the south, for brown coals and associated beds at Hunua and Drury which form the base of the Tertiary sequence thin out to the north (Laws, MS.) and are absent at Waikopua, whilst, as stated by Hutton (1871), the "Papakura Series," which overlies these coals conformably and is correlated with the basal Waitemata beds at Waikopua, increases in thickness to the south. During the early stages of submergence, rugged greywacke coasts at places such as Waikopua afforded sufficiently sheltered conditions to permit the formation of impure highly fossiliferous limestones of shallow-water facies but, as the transgression continued and the whole mid-Auckland area became submerged, deltaic deposits comprising the Waitemata Series and derived from the continued erosion of land surviving in the north-west gradually enveloped the whole area, including what is now the area of the Maraetai Hills, in a sheet of sediment.

During this phase of sedimentation, probably at the same time as the upper green sandstones at Waikopua were being deposited, for these, as pointed out by Park (1885), are slightly tufaceous in places, a series of volcanic eruptions broke through the floor of the shallow Waitemata sea, and supplied the volcanic material of the Parnell Grit horizon. It has generally been considered that this horizon is low in the Waitemata Series, but it is shown from the occurrence of Parnell Grit at an elevation of 400 ft. near Trig. 1078, and by considerations of dip at Buckland's Peninsula that the thickness of underlying sandstone—equivalent to the limestones and associated beds at Waikopua—is fairly considerable.

The deposition of Waitemata strata was brought to a close, probably in early Pliocene times, by the initiation of the great differential uplifts and minor flexures of the Kaikoura period of orogeny (Cotton, 1916) which culminated in the production of the great earth-blocks, bounded by profound fractures, that largely control the present structure of New Zealand. The various earth-blocks of the

present district arose along their bounding faults at this time, with the result that the Waitemata beds were uplifted to a great extent and have suffered almost continuous erosion ever since.

With regard to the nature of the Waitemata-Hokonui contact in the present area, it is probable that here, as elsewhere in New Zealand, the rocks of the "oldermass" were reduced to very low relief subsequent to the late-Mesozoic orogeny (Cotton, 1916), for a plain-like greywacke surface, stripped of its Tertiary cover, is preserved in the down-faulted floor of Kiripaka Basin (Fig. 15). At Omana, Waikopua, and in Ratahi Range, however, moderate relief at the time of submergence is suggested. It is possible that the uplift of early Tertiary times which resulted in the erosion of Onerahi beds further north-west may have affected the present area to an extent sufficient to produce strong youthful features in the marginal portions of the old land-mass, and that Waitemata transgression interposed before rejuvenation of topographical features was felt much beyond the lower reaches of the streams of that time.

Age and Correlation of the Waitemata Series.

The palaeontology of the Waitemata Series is still imperfectly known, pending the revision by competent workers of the lists of fossils published by Fox (1902) and Clarke (1905); it is therefore futile at present to attempt correlations with the stages of the well-established Oamaru sequence, and impossible to do more than assign the series provisionally to the Miocene.* In view, however, of the importance of the present area in this connection, the following resumé of the opinions of early writers on the question of the age and correlation of the Waitemata Series is of interest.

Following a study of foraminifera and polyzoa from the Orakei Greensand, Hochstetter (1864) placed the Waitemata Series in the Miocene, and with it, on the basis of their both containing *Pecten fischeri, P. zitteli* and *Vaginella,* correlated the limestones and associated beds to which Hutton later gave the name Papakura Series.

Hutton (1871) reported two unconformities in the Tertiary sequence south of Auckland City, one between the Brown Coal Series of Hunua and Drury and his overlying Papakura Series, and the other between the Turanga Greensand, which he included in his Papakura Series, and the overlying normal Waitemata beds. He disposed of Hochstetter's correlation of the Waitemata Series with the Papakura Series by proving a wider time range for the fossils concerned.

The work of the officers of the early Geological Survey in the mid-Auckland area appears to have been influenced by the Cretaceo-Tertiary hypothesis brought forward in 1867 and more fully defined in 1877 by their Chief, Sir James Hector, in an attempt to solve the problem presented by New Zealand post-Hokonui beds. The Geological Survey considered *Pecten zitteli* to be a typical Cretaceo-Tertiary fossil, and the presence of this form and certain stratigraphical evi-

*Since this was written a paper by Powell and Bartrum (1929) has appeared in which the basal Waitemata beds at Waiheke Island are correlated with the Hutchinsonian stage of the Oamaruian.

dence near Mercer led Cox (1877; 1877a) to classify the Waitemata beds and the Papakura limestone—placed by him above the Waitemata beds—as Cretaceo-Tertiary. In 1881, Cox altered his opinion and gave the age of the "whole Waitemata Series" as Lower Miocene, for, at Komiti (Pakaurangi) Point, Pahi and other localities in the Kaipara district, he found Waitemata strata containing *P. zitteli* and *P. fischeri* "associated with a great preponderance of Lower Miocene forms," resting unconformably on typical Cretaceo-Tertiary chalk-marls and hydraulic limestones (now referred to the Onerahi Series). In his Progress Report of that year, however, Hector (1881) insisted on dividing the Waitemata Series at the top of the Parnell Grit, for he still considered this horizon and underlying beds, which at that time included the Orakei and Turanga Greensands, to be Cretaceo-Tertiary and separated from the succeeding Waitemata (Miocene) sandstones and marls by an unconformity, as demanded by his hypothesis. On being sent to elucidate this point, Cox (1882); and later McKay (1884; 1888) concurred with Hector and Hutton as to the existence of an unconformity above the greensand at Turanga Creek.

In 1885 Hutton strongly attacked the inclusion in the Cretaceo-Tertiary of the Papakura Series, which was made to embrace, in addition to other beds, the Turanga and Orakei Greensands, for he considered the Orakei beds to be younger than the Turanga ones, and had proved the time-range of *Pecten fischeri* and *P. zitteli* to be greater than that held by the Geological Survey. He reasserted his view of 1871 that the Papakura Series was probably Oligocene and the Waitemata Series (including the Orakei Greensand), which he believed unconformably to overlie the earlier series, Upper Miocene.

Park (1886; 1889) made a distinct departure from the views of his colleagues of the Geological Survey by showing that there is an unbroken sequence from the base of the "Papakura Series" of Hutton to the top of the Waitemata Series, and classed the limestones at Papakura and Waikopua and the greensands at Turanga Creek and Orakei Bay as Lower Miocene, and the Parnell Grit and succeeding normal Waitemata beds, Upper Miocene. Support for Park's claim of conformity throughout the mid-Auckland Tertiary succession is given by Clarke in a contribution to a paper by Marshall, Speight and Cotton (1911), and still more recently by Laws (MS.), who has recorded for the Papakura-Hunua area a broadly conformable sequence from marine sandstones below the Brown Coals, through the Papakura Series, to the top of the Waitemata Series.

(3) POST-TERTIARY DEPOSITS.

Varied deposits, both sedimentary and volcanic, have accumulated in the present area subsequent to the extensive erosion suffered by Waitemata strata consequent on the Pliocene Kaikoura orogeny (Cotton, 1916) which terminated the Waitemata period of deposition.

Of most importance among the sedimentary deposits are the extensive pumiceous sands, silts and clays of the Manukau-Tamaki coastal lowlands, and the similar more localised deposits at Buck-

land's, Omana, and Wairoa Estuary. No internal evidence as to the age of these beds is available, but inasmuch as they rest unconformably on Waitemata strata—though occasionally, as at Wairoa Estuary, on Hokonui greywacke—and are not affected by the sharp dislocations produced in the older rocks by the Kaikoura orogeny, their provisional relegation to the Pleistocene is largely justified.

Other post-Tertiary deposits include large, low-lying pockets of clays in Waitemata strata near Whitford, partly or wholly Recent ubiquitous raised beaches and associated deposits, and such alluvial deposits as those of the Brookby Valleys, Whitford Valley, and the terraces at the mouth of Te Puru Stream.

Volcanic accumulations—tuff craters, flows of basalt, and scoria cones—attain some importance in the coastal lowlands, where they rest unconformably on the eroded surface of the Pleistocene sediments mentioned above. This relationship, supported by the fact that near Auckland City, as pointed out by Marshall (1908), the lava flows occupy the valleys of the present cycle, and by the freshness of the lavas and the well-preserved nature of the cones, justifies the allocation of these products of igneous action to either Recent or sub-Recent times. It may be remarked, however, that Turner and Bartrum (1929) hold the view that the volcanoes of the Takapuna-Shoal Bay area on the north shore of Waitemata Harbour were active at a time prior to the present cycle. This also appears to be the case for some of the tuff-cones of the present area.

Post-Tertiary History.

Before proceeding with a description of the sub-Recent volcanic accumulations it is proposed to attempt to trace the post-Tertiary history of the area and the development of certain of its present day topographical features from the evidence given by the post-Tertiary sedimentary deposits, and by comparisons with work done in adjacent districts.

Turner and Bartrum (1929), dealing with the Takapuna-Silverdale district, which has its southern and northern limits 10 miles and 20 miles respectively north of the present district, have interpreted the evidence available as indicating that, subsequent to the Kaikoura orogeny, prolonged erosion reduced the mid-Auckland area to a peneplain. Peneplanation was succeeded by long-continued uplift which resulted finally in a relative lowering of the strand-line by at least 600 ft. This uplift was broken by several periods of standstill of sufficient duration to allow the streams of that time to become graded with respect to the current sea-level, and to develop benches, still partially preserved, at elevations of approximately 350 ft., 100 ft. to 120 ft., 40 ft. to 60 ft., and 15 ft. to 20 ft. above present sea-level. The movement culminated in a rapid uplift of the order of from 150 ft. to 200 ft., as a result of which the streams of that time became entrenched in narrow, steep-sided valleys, and was closely followed by a negative movement of the land which resulted in the drowning of these youthful valleys and initiated the embayed coastline so characteristic of the western shores of Hauraki Gulf to-day. The only movement since this drowning has been an

uplift of from 5 ft. to 8 ft. in Recent times, clearly indicated by well-preserved raised beaches at numerous localities (See Figs. 6 and 8).

The course of events outlined above holds generally throughout the whole neighbourhood of Auckland City (Bartrum, 1922), and possibly, as indicated by the work of Smith (1881) and Henderson (1924), over a much wider area. By comparing all such evidence of post-Tertiary movements throughout New Zealand, Cotton (1916)*, Benson (1924) and Henderson (1924) have reached the conclusion that these were singularly constant, and of an epeirogenic rather than of an orogenic nature. Though this generalisation undoubtedly holds in major detail, considerable difficulty is experienced in connecting minor details of adjacent districts. Bartrum (1927) suggests that this is due either to incomplete evidence, or possibly to local variations produced as a result of dying movements of the Kaikoura orogeny along the original fracture lines. A small normal fault which cuts both Waitemata and Pleistocene strata near Beachlands Wharf (Fig. 18) gives support for the latter contention, for it may possibly have resulted from a final adjustment of the blocks produced during this orogeny, and indicates that simillar processes may have been at work in other localities during the Pleistocene.

Evidence bearing on early post-Tertiary history is scanty in the present area, but there is a moderately strong suggestion of an old erosion-level at an elevation of from 350 ft. to 380 ft. above sea-level in the sandstone hills immediately north of Great South Road between Wiri and Manurewa. The earliest period of standstill of which definite evidence is available is a minor one indicated by certain alluvial deposits exposed at an altitude of 180 ft. near the northern boundary of Manurewa Township, which appear in road cuttings as coarse-grained, frequently cross-bedded, thin strata containing plentiful roughly-rounded pebbles of hardened mudstone, and resting unconformably on beds of the Waitemata Series.

As elsewhere near Auckland City, a lengthy period of standstill is clearly indicated in the present area by erosion surfaces and alluvial and possibly fluvio-marine deposits at from 100 ft. to 120 ft. above present sea-level. Beds referable to this stage which are generally finer in grain but otherwise somewhat similar to those just described, appear along the base of Puhinui Range, passing from Wiri through Manurewa to a continuation in an extensive distinct terrace in the vicinity of Alfriston, 30 ft. above the level of the adjacent floor of Papakura Valley. It is to this stage also that Bartrum (1927) refers the formation of terraces of pumiceous silts, 80 ft. to 100 ft. above sea-level, on the west coast of Firth of Thames and the east bank of the estuary of Wairoa River, the material of which he believes to have been deposited in sheltered waters as the top-set beds of an ancient delta of Waikato River at a time when its course was through Hinuera Gorge and across the present Hauraki Plains to Hauraki Gulf (Cussen, 1889; 1894).

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*Cotton has introduced the term "post-Kaikoura movements" for these post-Tertiary oscillations of land and sea.

It is of interest to note that at the present time the central portion of the floor of Papakura Valley (Fig. 31) is at an elevation of 90 ft. above sea-level, but that towards both Hauraki Gulf and Manukau Harbour this is reduced gradually to approximately 50 ft. above sea-level. The greater part of this extra elevation appears to have been attained by the accumulation of successive comparatively recent swamps, which often entomb large forest trees, so that it is reasonable to assume that at the period under consideration a strait of the sea connected Hauraki Gulf with Manukau Harbour by way of the fault-angle depression of Papakura Valley. No wave-cut benches or other signs of such occupancy are, however, visible on the valley walls, though it is possible that a distinct terrace of appropriate elevation which partly occupies the floor of Lower Brookby Valley may represent an ancient delta of Papakura Stream formed at this time, whilst the existence of this strait would readily account for the presence of occasional strings of fine-grained pumiceous silts in the "100 ft. to 120 ft." deposits along the base of Puhinui Range, for, as has been shown above, Waikato River at this time flowed into Hauraki Gulf.

A further period of standstill co-ordinated with deposits and erosion-surfaces from 40 ft. to 60 ft. above sea-level is admirably shown by the deposits of the extensive Tamaki-Manukau coastal low-lands, by the Pleistocene beds at Omana, Wairoa Estuary, and Beachlands, and by an erosion-level clearly demonstrated not only on the mainland at Beachlands and Buckland's, but also in Motu-karaka, Motuihi, and other islands nearby in Hauraki Gulf.

During this phase the Waikato River appears to have made one of those changes in its course noted by Cussen (*loc. cit.*) and, leaving Firth of Thames, flowed into an immense shallow estuary, now partly represented by Manukau Harbour, depositing therein the series of finely-bedded, fine-grained, soft pumiceous sands or silts which characterise the coastal lowlands. These beds grade from unconsolidated sands of almost pure pumice and occasional bands of fine pumiceous conglomerate, to plastic clays containing considerable plant material and, though everywhere cross-bedded on a fine but distinct scale, are essentially horizontal throughout. Certain coarse alluvial deposits incorporated with the finer-grained ones, such as are exposed at the railway bridge over Papakura Stream, probably represent the deltaic accumulations of small streams draining into this shallow estuary from the adjacent hills of Tertiary sandstone.

Other distinctive associated beds are certain "peat-like lignite bands" which are extensively exposed on the banks of Tamaki River, north of Panmure Bridge. They were first recorded by Hochstetter (1864, p. 62), who regarded them as so characteristic that he gave the name of "Lignite Formation" to the whole series of pumiceous beds filling this early estuary of the Waikato.

Interesting sidelights upon the early history of the present area may be drawn from certain features of the beds belonging to this "40 ft. to 60 ft." series of terraces at Beachlands, on the Hauraki Gulf coast. Near the wharf, about 15 ft. of thick greenish clays, interbedded with two thin bands of pure pumiceous silt,

underlie the plain-like surface of the area at an elevation of about 40 ft. above sea-level, and rest highly unconformably on the denuded edges of underlying Waitemata strata. In the bay to the east, however, these Pleistocene beds grade down through fine-grained conglomerates to rapidly-changing lenses of stream-derived greywacke gravels and coarse sandstone conglomerates which rest on a water-worn surface of Waitemata sandstone in which are preserved several perfect "fossil" pot-holes up to 18 in. in diameter and 6 in. in depth (Fig. 16). It is apparent that this surface, which is approximately at present day high-water mark, was cut by the same stream that later deposited the overlying gravels. Further, it could only have been carved when the sea-level was the same or lower than that of to-day, and it therefore appears that the uplift subsequent to the formation of the "100 ft. to 120 ft." benches and terraces must have continued till the strand-line was at approximately the same elevation as at present, with consequent appropriate down-cutting of the streams of the time, and that subsidence then intervened and continued until the strand reached an elevation consistent with the "40 ft. to 60 ft." deposits. At the eastern end of the bay, a bed of lignite, composed almost entirely of sedges (Raupo or *Typha angustifolia*), and obviously representing an old swamp accumulation, occurs at the base of the series and corroborates the evidence of the fossil pot-holes. The low disposition of these deposits is clearly shown to be quite unrelated to sub-Recent fault movements.

Turner and Bartrum (1929) have found similar evidence in the Pleistocene beds bordering the upper reaches of Waitemata Harbour, of comparable fluctuations of the strand-line prior to the formation of the "40 ft. to 60 ft." terraces.

The beds of the so-called "30 ft. to 35 ft." terrace of Lower Wairoa River are also to be correlated with those of the coastal lowlands, and are characterised by fine, closely-laminated and cross-bedded pumiceous silts, grey muds, and occasional bands or strings of fine pumiceous conglomerate (Fig. 17). At the present time this terrace forms a practically continuous fringe along the base of Pukekawa Range, which follows the line of Lower Wairoa Fault from Clevedon to Duder's Beach, and terminates abruptly eastward against the low swampy flats of the modern delta of Wairoa River. It is apparent, therefore, that movement along Lower Wairoa Fault, which defines the eastern limit of the Maraetai Hills block, had ceased before these Pleistocene beds were deposited, for they lie in a distinct re-entrant, cut most probably by wave erosion, in the face of the greywacke hills near Clevedon. Sandy beds containing numerous rounded pebbles of greywacke are common amongst the material of this terrace, and undoubtedly represent fans deposited by streams draining the scarp during the time of the accumulation of the pumiceous silts.

Bartrum (1927) has traced this same terrace from Clevedon along the east bank of Lower Wairoa River, and has also identified it at several places along the western shores of Firth of Thames.

Although it is probable that at this time Papakura Valley was still occupied by a strait of the sea in which beds of the same series as those of the coastal lowlands were deposited, it is not necessary to postulate that the pumiceous material of these "30 ft. to 35 ft." terraces was transported across this waterway from the ancient Manukau estuary. During the uplift subsequent to their deposition, the older pumiceous beds of the "80 ft. to 100 ft." terraces recorded by Bartrum (1927) from the Clevedon area undoubtedly suffered enormous erosion, and their upper portions were entirely removed from the base of Pukekawa Range. The material thus set free would be available for re-deposition elsewhere at lower levels, while many of the "30 ft. to 35 ft." terraces were probably directly carved out of the earlier pumiceous deposits either by stream or wave erosion.

After the deposition of the pumiceous beds just discussed, uplift recommenced, but was interrupted by a minor period of standstill when the sea stood approximately 20 ft. lower than previously, and probably 20 ft. above that of to-day. It then continued rapidly until it attained a maximum of perhaps 200 ft., causing sharp entrenchment of the streams of the time, and was almost immediately succeeded by depression of approximately the same magnitude, which produced extensive drowning of the rejuvenated valleys, and laid the foundation of the major modern coastal features.

The history of Manukau Harbour is largely bound up with the sub-Recent movements of the land subsequent to the deposition of the deposits of the plain-like coastal lowlands that have been discussed, for much of its extent is due to the rapid erosion by waves of these soft deposits subsequent to the drowning of long, deep valleys cut across them as a result of the uplift which closed the period of their deposition. The long tidal estuaries of the modern Manukau Harbour coastline represent merely the upper reaches of the original drowned valleys, and have themselves been greatly widened by wave erosion. It would appear that the Waikato River was localised in its present course at the southern margin of its ancient estuary at some time during these movements by outpourings of basaltic lavas in the Lower Waikato Basin.

The only other diastrophic movement to affect the district has been a minor uplift of from 4 ft. to 8 ft. in Recent times. This is clearly shown by raised beaches backed by abandoned sea-cliffs in the majority of the bays and other sheltered sections of both the Hauraki Gulf and Manukau Harbour coasts, and by occasional benches of alluvium bordering certain of the streams. A particularly fine example of these raised beaches stretches almost across the base of Buckland's Peninsula. It is one mile long and as much as one-quarter of a mile wide, and everywhere displays shell deposits characteristic of fairly steep beach débris. Similar shell beds form an extensive slightly-elevated strand-plain bordering the whole length of Duder's Beach.

At the eastern portion of Omana Beach, old beach deposits of this stage are exposed resting, with the interposition of about one foot of coarse, iron-cemented greywacke beach-conglomerate, on a bench two or three feet above high-water mark which has been carved by wave-erosion upon a local occurrence of estuarine muds and

associated beds of the "40 ft. to 60 ft." stage (Fig. 8). These shell beds merge to the east into a corresponding wave-cut platform 100 ft. wide which is carved in the greywacke of Maraetai Point (Fig. 7) and is there succeeded upwards by a remnant of an earlier bench cut at that period of standstill mentioned on an earlier page when sea-level was 20 ft. above that of the present day. Similar juxtaposition of evidence of these two periods is to be seen in two clearly-defined terraces of appropriate elevation at the mouth of Te Puru Stream (Fig. 34), which probably are remnants of deltas developed with respect to these two base-levels.

Sub-Recent Volcanic Accumulations.

Of the 63 separate points of eruption recorded by Hochstetter (1864; 1867) within a 10-mile radius of Auckland City, 17 are located in the coastal lowlands of the present district. Of these latter, 7 are grouped in Mangere-Ihumatao area, 5 are in the vicinity of Papatoetoe, and 4 more form a group at East Tamaki.

The normal order of events in the history of these volcanic centres appears to have been (1) The formation of an explosion-crater surrounded by a low tuff-ring. (2) Outpourings of basaltic lavas. (3) The building of numerous scoria cones. This complete sequence is to be seen at Puketutu, Maungataketake, Crater Hill, Otara, and Pigeon Hill, but considerable variation from it is shown by other centres. Thus Mangere Basin and Waitomokia have small scoria cones rising out of the floors of explosion craters; Pukaki Basin, Kohuora, Styak's Swamp and Pukekiwiriki are only tuff cones, whilst lava flows associated with scoria cones, with no evidence of an original explosion crater, are to be seen at Mount Mangere, Puke-iti, Otuataua, Wiri Mountain, Matukurua, and Green Hill. Brief descriptions of each of these points of eruption will be given later.

As stated previously, it would appear that this volcanic activity generally took place in sub-Recent times, but there is, however, evidence in at least two localities that it probably commenced either prior to or contemporaneously with the building of the "40 ft. to 60 ft." terraces of post-Tertiary times. Turner and Bartrum (1929) have demonstrated this possibility in the case of two calderas at Shoal Bay, on the north shore of Waitemata Harbour, whilst in the present area, in the vicinity of Panmure Bridge, the surface of tuffs derived from Panmure Basin—a large caldera west of Tamaki River—is so perfectly continuous with that of Pleistocene beds of the Tamaki-Manukau coastal lowlands as to suggest that this is more than mere coincidence, as it must be if the tuffs are truly sub-Recent. It is clear that the eruption from Panmure Basin preceded the major final phase of uplift of the area that was followed by the important sub-Recent submergence to which the present coastal features are primarily due, for Tamaki River represents a valley, drowned by this submergence, that has been incised in the tuffs in common with the adjacent pumiceous beds. It will be shown later that similar evidence is afforded at Pukaki Creek.

In this connection it is of interest to note that Shrewsbury (1892), following Hochstetter (1864; 1867), explained the perfect bedding displayed throughout the tuff-cones in the vicinity of Auckland

City by suggesting that the outbursts—probably paroxysmal—which formed them were largely submarine, though in shallow water. In certain cases this may be correct, for shells have been recorded from some of these tuffs, but the bedding can be equally well explained as the result of subaërial settling, in the vicinity of the vents, of the débris ejected by the explosions.

Petrography of the sub-Recent and Recent Lavas.

Samples from practically all of the basaltic flows in the present district have been studied in thin section under the microscope and have shown the lavas to be closely similar to, though on the average more basic in composition, than those further north nearer to Auckland City. They are typically holocrystalline, olivine-rich basalts, in which prominent sub-idiomorphic phenocrysts of olivine and augite, in sub-equal amounts, are set in a groundmass of plagioclase laths, augite, and grains or small well-formed crystals of magnetite. Augite is the only mineral to occur in two generations. It is of the titaniferous variety, characteristically shows hour-glass structure, and not infrequently occurs in aggregations or intergrowths of numerous small idiomorphic crystals. The plagioclase appears to be moderately basic labradorite, and normally occurs in comparatively long, slender, irregularly-arranged laths, which are often ophitically enclosed by augite or are squeezed between small augite crystals. A moderate amount of residual glass occurs in the groundmass of basalt from Otuataua.

As is to be expected, great variations in texture occur in different flows, and also in different parts of the same flow. The lavas of Green Hill (Fig. 37) and Crater Hill are sufficiently coarse-grained to enable approximate micro-analyses to be made, the results of which indicate them to be normal basalts, though with a somewhat low iron-ore content. Both rocks show large idiomorphic crystals of olivine and augite set in a coarse groundmass of irregularly-arranged long slender laths of plagioclase, small crystals and grains of augite, and subordinate magnetite.

A Wentworth recording micrometer was used in making the analyses, and traverses were made across the slides at intervals of 0.5 mm. The results obtained must be regarded as approximate only, for in places the grain of the groundmass is too fine for accurate measurement, and occasionally lack of definition of magnetite not only makes determination of this mineral difficult, but also clouds the limits of adjacent augite and plagioclase. Further, both rocks are vesicular, and in some cases it is not certain whether holes in the sections are original or due to fritting of phenocrysts during grinding. With olivine, therefore, which occurs in one generation only, the interpretation placed on the nature of these holes may greatly affect the final result. Nevertheless, it is believed that the following figures indicate fairly closely the composition of these rocks. In obtaining them, the compositions of the various minerals have had to be assumed. The only analysis available of the minerals of Auckland sub-Recent basalts is that of olivine from nodules at Takapuna (Turner and Bartrum, 1929). This has been adopted for the olivine

in the present slides. For the augite, the mean of six analyses of titaniferous augites given on p. 361 of Dana's "A System of Mineralogy; Descriptive Mineralogy," 6th edition (1909), has been taken. Plagioclase has been taken as being labradorite $Ab_1 An_2$, a procedure justified by extinction angles of up to 35° on albite twin-lamellae, and its composition has been worked out from analyses on p. 327 of Dana's book.

The results obtained are as follows:—

Green Hill Basalt.

		SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	TiO_2
Augite ...	(50.90%)	24.35	2.68	3.01	2.64	5.76	11.08	—	1.38
Olivine ..	(15.43%)	6.51	0.07	0.02	1.33	7.42	0.05	0.02	0.01
Plagioclase ..	(27.18%)	13.96	8.47	—	—	—	3.72	1.03	—
Magnetite ...	(5.79%)	—	—	4.00	1.79	—	—	—	—
	(99.30%)	44.82	11.22	7.03	5.76	13.18	14.85	1.05	1.39

Crater Hill Basalt.

		SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	TiO_2
Augite ..	(51.37%)	24.56	2.71	3.07	2.66	5.81	11.17	—	1.39
Olivine ...	(9.69%)	4.09	0.04	0.01	0.84	4.66	0.03	0.01	0.01
Plagioclase ...	(32.28%)	16 58	10.06	—	—	—	4.41	1.23	—
Magnetite ...	(6 08%)	—	—	4.20	1.88	—	—	—	—
	(99.42%)	45.23	12.81	7.28	5.38	10.47	15.61	1.24	1.40

Exceptionally basic or limburgitic basalts, of no great extent, however, occur at Maungataketake (Fig. 38) and Matukurua. Both rocks show scattered phenocrysts of augite and olivine in a fine-grained groundmass consisting essentially of augite and magnetite. Though the groundmass is too fine-grained to test for analcite by ordinary methods, yet the almost complete absence of plagioclase is sufficient to indicate limburgitic affinities. An extensive flow of moderately coarse-grained basalt from Puke-iti also appears to be more basic than the average. In this rock olivine phenocrysts are abundant, whilst in the groundmass plagioclase is subordinate to augite, and magnetite, usually in well-formed crystals, is plentiful.

Marshall (1908), in a resumé of the sub-Recent basalts of mid-Auckland, classed them all as basanites as a result of gelatinization and staining tests made on samples collected over a wide area from Auckland City south to Waikato Basin. A doleritic basanite does occur at the Domain, Auckland, but otherwise, in the vicinity of Auckland City at least, there appears to be little support for Marshall's generalization.

The Volcanic Centres.

Brief descriptions of the various volcanic centres, which may readily be located by reference to the accompanying map, will now be given, commencing with those in the Mangere district.

Mount Mangere.

This is the largest cone in the district; its eastern wall is extensively breached, but its western rim is intact and rises to a height of 350 ft. above sea-level; a considerable portion of its centre is occupied by a large, splendidly preserved crater, from the floor of which rises a perfect small cone (Fig. 19) with two minor explosion pits. A smaller, deep crater occupies a position at the northern margin of the breached eastern wall of the main cone, whilst a shallower one occurs nearby on its northern flanks. Stretching eastward from the breach there are a series of jumbled mounds of scoria and tumuli of scoriaceous basalt, beyond which is a small, localised flow of basalt, whilst at the base of the mountain, on its north-east side, there is a small cone of well-bedded scoria which also appears from the bedding to have been breached to the east. On its western side the main cone rises abruptly above a wide, low-lying, gently-sloping surface apparently underlain by highly scoriaceous basalt and occasional tuffs which represent the initial stages of activity.

Mangere Basin.

This basin (Fig. 20) lies at the southern base of Mount Mangere and is a distinct shallow caldera 600 yds. in diameter. Its low tuff-ring has been breached on its south-western side and its crater has been filled almost to high-water mark with marine muds which encircle

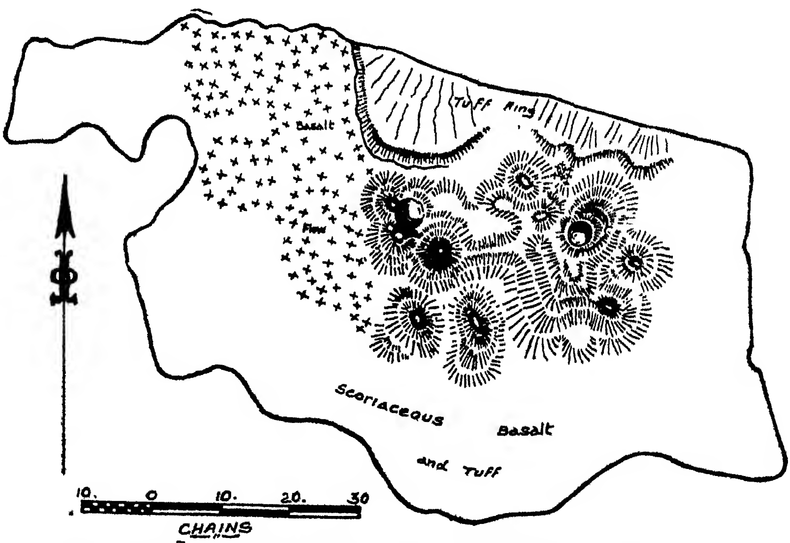

FIG. 3.—Sketch-map of the volcanic accumulations of Puketutu.

a low scoria cone, 20 ft. high, which forms an island in the centre of the circular crater floor. Tuffs derived from this centre of activity are widespread, well bedded and generally fine-grained, and contain an amount of volcanic lapilli which is large as compared with that of sedimentary débris.

Puketutu (Week's Island).

The sketch-map of Text-Fig. 3 shows the general arrangement of the various volcanic accumulations of this island, which is one of the most interesting localities of the district.

The first phase of activity was apparently the production of a large explosion crater and tuff-cone, the sole surviving evidence of which are certain fragments of the tuff-ring preserved along the northern side of the island, where as much as 30 ft. of tuffs are exposed. These are similar to those at Mangere Basin, but also contain occasional blocks of scoriaceous basalt. At several points along the southern shore, however, the tuff is again visible, though overlain by irregular flows of scoriaceous basalt which form an extensive low-lying gently-sloping border to the island.

Near the centre of the island an interesting series of scoria cones rise above this floor of scoriaceous basalt, the highest reaching 260 ft. above sea-level; they are obviously not the products of a single eruption. Except for two sharp, craterless cones on the south of the group, the several cones are connected and form a somewhat confused series of scoria peaks and ridges, the westerly members of which form the southern rim of a shallow crater, now breached on its north margin.

The most interesting cone of the series is at the north-east corner of the group. A well-defined crater at one time occupied its crest, but was later largely obliterated by a small cone, cupped by a shallow crater, which rises from its interior and over-rides the earlier crater rim to the south-west, leaving only a north-east remnant of this latter.

A moderately extensive basaltic flow occupies the western end of the island, whilst large blocks of basalt are plentiful in the westerly members of this group of scoria cones and ridges, though fine scoriae alone characterise the easterly members.

Waitomokia (Gabriel Hill).

Waitomokia is a perfect tuff-ring almost one-half mile in diameter which rises 70 ft. above sea-level and encloses a crater, now occupied by a swamp, in the centre of which there is a group of three small scoria cones (Fig. 21). These latter attain an elevation of 120 ft. above sea-level, or 80 ft. above the crater floor, the crest of the most southerly one possessing a deep, symmetrical crater. The tuff comprising the crater-rim is similar to that at Puketutu, and at Oruarangi Creek is overlain by extensive basaltic flows from Puke-iti.

Puke-iti.

This is a low, symmetrical, saucer-shaped scoria hill with its crest entirely occupied by a comparatively wide but shallow crater. An extensive lava flow extends from it northward to Oruarangi Creek and westward to the shores of Manukau Harbour.

Otuataua (Quarry Hill).

Otuataua (Fig. 22) is a scoria cone rising 200 ft. above sea-level immediately south of Puke-iti. A small shallow crater, breached to the north-west, occurs near its summit, whilst a thick but limited flow of basalt, apparently overlying that from Puke-iti, extends west from its base to Manukau Harbour. The constituent well-graded and well-bedded scoriae are well displayed in a large quarry on the south face of the cone.

Maungataketake (Ellett's Mountain).

This is a double cone three-quarters of a mile south-west of Otuataua; a sharp craterless peak 230 ft. high has risen out of and largely obliterated the extensive shallow crater of an earlier but much lower cone, overlapping the eastern rim of the older crater, whilst the distinct western portion of the rim is cupped by a subsidiary crater. Blocks of scoriaceous basalt litter the slopes of the lower cone, but the only visible flow is a small one on its western side, near Manukau Harbour. A low tuff-ring partially encloses Maungataketake on the north, and it is traceable by frequent exposures of tuff and volcanic agglomerate at sea-level also on its southern and western margins. It evidently was formed during a very early phase of activity at this centre.

Pukaki Basin (Motor Speedway).

This is a splendid sub-circular caldera (Fig. 23), approximately 600 yds. in diameter, which is flooded by the sea at high water, and drains into Pukaki Creek through a narrow gap in its south-east margin. The mangrove swamp which now occupies its floor is enclosed by almost sheer walls of tuff 30 ft. to 40 ft. high, which are succeeded north-westward by higher ground rising to an elevation of 100 ft.

The tuffs forming the crater-rim are well-bedded, reddish-brown in colour, and usually contain some comminuted sandstone and other sedimentary material greatly in excess of volcanic matter, though there are occasional bands wholly composed of rounded scoriae ½ in. in diameter. In some cases the volcanic material is very dense and glassy, approaching tachylyte in nature, and undoubtedly represents rapidly cooled drops of lava thrown out liquid during the eruption. At several points around the base of the inner crater walls, the tuffs are seen to rest on pumiceous silts which represent the pre-volcanic basement.

Crater Hill.

This centre of eruption (Fig. 24), 1½ miles west of Papatoetoe, is one of exceptional interest. Its history appears to have been (1) the formation of a large explosion crater 500 yards in diameter and of an encircling perfect tuff-ring at least one-half mile in diameter (2) the upwelling of basaltic lava into the crater to form a level rock-floor (3) foundering of a considerable portion of the centre of this floor, leaving a distinct frozen ledge 2 chains or 3 chains wide against

the tuff-rim. This was a result of withdrawal of lava in a manner reminiscent of events at Kilauea, perhaps by the initiation of activity at neighbouring volcanic centres.* (4) the building of a cone of fine, well-graded and well-bedded scoriae rising perhaps 70 ft. above the floor of the crater immediately north-west of the foundered section. This may have preceded stage (3) and its building have contributed to the withdrawal of lava evidenced by the foundering of the floor, but from the smallness of the cone it appears unlikely that this has been the only factor concerned.

The tuff-ring of Crater Hill rises to an elevation of 120 ft. above sea-level and is from 30 ft. to 50 ft. above the crater floor. The tuffs themselves are splendidly bedded in layers from ½ in. to 3 in. thick which dip towards the crater on the inside of the rim, though radially outwards elsewhere, and consist dominantly of rounded basaltic lapilli with subordinate sedimentary material, though large blocks of scoriaceous basalt are occasionally met with adjacent to the crater. Other inclusions noticed in well-exposed sections around the shores of Pukaki Creek include small spheroids of basalt enclosing fragments of sandstone, and lumps of Parnell Grit roughly rounded by attrition. The former rarely exceed 2 in. in diameter, but the latter are in some cases as much as 6 in. These Pukaki Creek sections are also interesting in that they show the tuffs resting on a somewhat irregular erosion-surface of the pumiceous silts which varies in altitude from sea-level to about 10 ft. above this latter. Two interpretations of this relation are possible: either that the pumiceous beds had been built up to their normal greater height above sea-level and then eroded by streams prior to the volcanic outburst, or that this latter took place before deposition of the subjacent silts had developed the higher remarkably level plain normally constituted by these beds. Topographic evidence in favour of the first alternative is absent, and it appears preferable, therefore, to conclude that here, as at Panmure Bridge, there is evidence that certainly not all of the volcanic eruptions of the Auckland district are as late an event as is generally believed.

In places, the clays beneath the tuffs show definite prismatic structure at the contact and thus indicate that these latter were ejected as showers of hot ashes.

The foundered section of the crater floor of Crater Hill is now occupied by a swampy lake of unknown depth, with its shores constituted by vertical walls of lava 10 ft. high and with a small residual island at its north-west corner. The upwelling of the lava did not precede the formation of the tuff-ring, for, had no barrier existed, a thick flow such as that which occupies the crater floor would inevitably have escaped to the much lower ground on the outer confines of the tuff-cone, and no trace of such lava has been found. In addition, the relations of the wide central rock-bench to the tuff-cone can be reasonably explained only if the sequence of events has been as suggested.

*The general petrographical uniformity of mid-Auckland basalts indicates their connection with one common source of supply, probably a large sill under the area, as suggested by Marshall (1912, p. 106).

Kohuora.

This name is applied to two somewhat irregular depressions and their encircling subdued hills which occur immediately south-west of Papatoetoe township. These depressions are undoubtedly explosion-craters, for although the material comprising the surrounding hills is generally ill-assorted and so deficient in volcanic material as scarcely to warrant the term volcanic tuff, yet the presence in it of occasional well-defined thin bands containing dominant small scoria fragments, as revealed in adjacent railway cuttings and in well-borings, and the fact that the hills rise appreciably above the general level of the coastal lowlands is at least suggestive if not definite proof of their volcanic origin. Not far distant there is a perfect, small explosion-crater little more than 50 yards in diameter and only 10 feet deep, which occurs immediately west of the railway midway between Papatoetoe and Puhinui railway stations. At Kohuora and also at Pukaki Basin, activity must have taken the form of steam explosions mainly confined to shattering the sedimentary beds above subjacent liquid rock.

Wiri Mountain (Manurewa).

This elevation is a scoria cone, 300 ft. high, which is now considerably defaced by quarrying operations. It is surrounded by extensive basaltic flows, whilst the remnant of a small summit crater is still to be seen at the head of the main quarry on the north-east face of the mountain. This quarry also reveals irregular masses of highly scoriaceous basalt traversing the scoria in the vicinity of the old vent, and at its entrance shows a sub-horizontal sheet of basalt overlying steeply-inclined, well-bedded scoriae. This is unusual in the local cones, and demonstrates that there have been periods of cone building alternating with outpourings of lava in the history of the mountain.

Matukurua (McLoughlin's Hill).

This is a scoria cone rising approximately 200 ft. above a somewhat limited, low-lying floor of scoriaceous basalt, one mile south-west of Wiri Mountain, and immediately beyond the basaltic flows from that centre of eruption. The symmetry of the cone is broken by a large, extensively-breached crater which occupies its southern face, and by a jumbled group of scoria mounds which stretch from this breach to the mouth of Puhinui Creek. The constituent material of the cone, as displayed in a small quarry on its north face, is seen to be well-bedded scoriae and numerous irregular, twisted masses and ill-formed bombs of highly scoriaceous basalt which attest to the ejection of lava in a semi-plastic state. The surfaces of the larger bombs are frequently studded with lumps of scoria, apparently caught up by the plastic masses as they rolled down the flanks of the growing cone.

Otara (Smaile's Hill).

Otara is a scoria cone (elevation 320 ft.) showing perfect contours when regarded from the west, but flanked on the east by a group of irregular scoria mounds apparently produced by the breach-

ing of the eastern rim of a small crater near its summit. The eastern half of the hill is margined by a typical, low, tuff-ring (Fig. 25), which merges into its northern slopes, whilst the southern end of the ring, on which historic Smaile's church is situated, is connected with the main cone by a low scoria mound. Small flows of basalt pass around the southern extremity of the tuff-cone and extend a short distance out on to the neighbouring lowlands. Several strong springs of water issue from under the lava at the base of the western slope of the main cone.

Green Hill.

Like many others, this hill has been greatly defaced by quarrying operations upon the evenly-bedded, well-graded scoriae of which it is composed. The summit of the main cone is at an elevation of 260 ft., and is partially occupied by a shallow, symmetrical crater. A smaller, craterless cone is situated immediately north of the main one, whilst a third, little more than a mound, lies at the base of its eastern face, and is separated from it by a low-lying, shallow crater. An extensive flow of coarse-grained basalt, approximately 15 ft. to 20 ft. in thickness, extends from Green Hill to Pakuranga Creek, and at Green Hill "bluestone" quarry, one-half mile west of the cone, is seen overlying Pleistocene pumiceous silts.

Styak's Swamp.

This centre of activity, which is situated immediately north of Green Hill, is a small perfectly-preserved explosion-crater, approximately 100 yds. in diameter, with its floor occupied by a swamp and enclosed by a continuous tuff-ring not over 20 ft. in height. The tuff is typically in very thin beds and contains numerous fine-grained sandy bands. The included volcanic material is never greater than ¼ in. in diameter.

Pukekiwiriki.

The name Pukekiwiriki is applied to a low, subdued hill on the north bank of Otara Creek, near the confluence of this stream with Tamaki River; it rises definitely above the general level of the surrounding coastal lowlands, which fact, in conjunction with the evidence given by beds of sandy volcanic tuff which overlie Pleistocene beds along the adjacent shores of Otara Creek, immediately suggests that it is of volcanic origin. The centre of eruption appears to have been a small, low-lying explosion crater, now largely destroyed by stream-erosion, which lies alongside Otara Creek on the south-east flanks of the hill now described. Tuffs erupted from this point have only minor development on its south-east margin.

Pigeon Hill.

This is a small scoria cone situated immediately east of Tamaki River 3 miles from its mouth; it rises to a height of 180 ft. above sea-level, and is partially encircled to the north-east by a well-defined tuff-ring. A small crater, breached to the west, occupies its western

flanks, and reveals the coarse, ill-graded scoriae and irregular sheets and dykes of scoriaceous basalt of which the cone is comprised. No marginal flows of basalt occur at this centre.

Detailed Physiography.

The generalised physiographic description of the present district given previously needs amplification in order to bring out more fully interesting peculiarities of certain areas; this will be done by detailed reference to the various physiographic units, which, with their bounding fault-fractures, have already been introduced.

1. Maraetai Hills Earth Block.

The state of homogeneity to which the greywacke that forms the basement rock of the Maraetai Hills has been reduced by its prevalent close jointing is such that the effects of all structural features, other than strong fractures, are negligible. With the exception, therefore, of such cases as Waihohono Block and the middle reaches of Ruatawhiti Stream, where, as will be shown later, structural control is apparent, the drainage pattern of the block is typically dendritic, and the streams insequent. The whole block is maturely dissected, the topography fine-textured, and the streams typically in the stage of late youth or early maturity in that they display series of short, graded reaches separated by falls or rapids which are usually associated with master-joints in the greywacke. Normally the slopes of the valley walls are graded, and the valley cross-profiles moderately sharply V-shaped, but in deforested areas extensive slipping of the residual clay cover is general, exposing the decomposed underlying rock.

The central portion of the Maraetai Hills exhibits a special feature in that, over a moderately large area, the summits of divides show a close accordance to a level of approximately 500 ft. above sea-level, which is accentuated by the fact that the surrounding hills, especially to the north and south, rise a further 100 ft. to 200 ft. This feature is apparently an example of what Cairns (1912) has termed "equiplanation," for the conditions obtaining agree with those believed by Davis (1923) to be essential for such a development, namely, a maturely dissected area drained by more or less equally spaced and equally dimensioned streams—in this case, headwater tributaries of Waikopua, Papakura, and Ruatawhiti Streams—the valley slopes of which are in a graded condition and have equal declivities.

2. Whitford-Brookby Earth Block.

The chief modifications of the general physiographic features already described as characterising this topographical unit arise along the course of Papakura Stream—in the Brookby Valleys—in Whitford Valley, and in the valley of Puhinui Stream, and will therefore be dealt with under these locality headings.

Papakura Stream and the Brookby Valleys.

Papakura Stream, which is by far the largest in the present district, rises in the Maraetai Hills, and leaves this elevated block in a narrows which cuts across the scarp of Clevedon-Waikopua Fault and displays sub-mature features in strongly developed meanders incised in the greywacke basement. On entering the eastern corner of the Whitford-Brookby earth-block the stream has developed two intermontane valleys, known respectively as Upper Brookby Valley, which is roughly 2½ miles long and half a mile wide, and Lower Brookby Valley, only one mile long, which lie from 200 ft. to 350 ft. below the crests of the bordering Brookby and Ratahi Ranges, and are separated, one from the other, by a low greywacke ridge breached by the stream in an unimpressive, narrow, but shallow gorge.

The course of Papakura Stream from the Maraetai Hills to its mouth is characterised by profuse meanders and occasional cut-offs and small ox-bow lakes, and shows a marked tendency to swing to the north-west against the bases of Ratahi and Puhinui Ranges.

The downstream margin of Lower Brookby Valley is defined only by the roughly-aligned, sudden terminations of the abruptly-rising greywacke hills of Brookby Range to the south-east, and of low greywacke foothills of Ratahi Range to the north-west. It is worthy of note that no greywacke appears in Ratahi Range or Puhinui Range south-west of this line or its continuation, and this suggests the possibility of a fracture at this point, trending roughly parallel to Clevedon-Waikopua Fault, the downthrow side of which is also to the south-west. However this may be, the immediate result of this rapid change in rock facies is that on leaving Lower Brookby Valley, Papakura Stream, again expressing its tendency to migrate to the north-west, has formed a deep embayment into the sandstone hills of Puhinui Range, from which it returns further downstream, still skirting the hills, to the approximate line of Papakura Valley Fault as given by the south-east scarp-face of Brookby Range. This embayment is continuous with the encroaching lowland plain of Papakura Valley, from which also the floor of Lower Brookby Valley is but imperfectly separated.

Upper Brookby Valley presents all the features of an aggraded depression, filled mainly by Papakura Stream—a flood plain of this stream constitutes the main floor—and to a lesser extent by gently sloping piedmont alluvial fans developed by tributaries draining across the valley from the bordering hills. The cross-profile of the valley is distinctly unsymmetrical as a result of the proximity of Papakura Stream to its north-west margin, and the consequent limitation of the fans on this side. The main floor rises at a gradually increasing gradient from an elevation of 120 ft. above sea-level at its downstream margin to 250 ft. against the Maraetai Hills. The steeper upper portion represents an extensive fan of Papakura Stream, which has been built sufficiently rapidly to force the lower courses of several adjacent tributaries down the main valley, and in one case has produced minor ponding.

From the evidence available it would appear that the depression now occupied by the Upper Valley originated during the period of block-faulting which gave rise to the several earth-blocks of the

district, as a result of back-tilting of a valley of the pre-faulting surface against the rising Maraetai Hills Block in consequence of a general tilt to the north-north-west given to the Whitford-Brookby Block at this time. Evidence of such a tilt is fairly complete, and will be given in a later section. The depression was undoubtedly originally occupied by a lake, which overflowed across the low ridge forming its downstream border, but which was soon obliterated by débris from the adjacent elevated Maraetai Hills poured into its head by the ancestral Papakura Stream. Filling would then proceed by the formation of alluvial fans and flood-plains until a graded profile, such as approximately has now been attained, was established throughout the length of the valley. Lowering of the outlet has at no time been able to keep pace with, much less to exceed the rate of deposition of alluvium, for nowhere are these deposits terraced as would undoubtedly be the case had this condition held. The level of the adjacent floor of Lower Brookby Valley would, in any case, exercise a controlling influence on the extent of degradation at the outlet gorge of the Upper Valley, and at the present time is only 10 ft. lower than the floor of the Upper Valley immediately upstream of the intervening barrier.

The early history of Lower Brookby Valley was probably similar to that of the Upper Valley, for the presence in the middle of its downstream margin of a low mound 15 ft. high which is probably composed of greywacke, indicates the existence at this point of a now-buried spur. In more recent times, however, its development must have been affected by such movements of the strand-line as have been indicated when dealing with the post-Tertiary history of the district. It has been shown that at one time the sea stood approximately 100 ft. above its present level and that at this period the present site of Papakura Valley was occupied by a strait of which Lower Brookby Valley probably formed a sheltered arm. Bordering Papakura Stream near the downstream margin of the Lower Valley and rising from 6 ft. to 8 ft. above its present flood-plain, which is continuous with the floor of Papakura Valley, there is at the present time a distinct terrace at an elevation of approximately 100 ft., which grades gradually into piedmont alluvial fans along the valley walls and occupies the greater part of the floor of the valley. This is believed to represent a delta of Papakura Stream formed during this period. During ensuing uplift the stream would cut a trench through these deltaic deposits, but in Recent times, as a result of the extensive filling in of Papakura Valley by alluvial and swamp deposits, it has been forced to aggrade this section of its course until but little trace of this trench now remains, and the surface of the ancient delta constitutes a distinct terrace only a few feet above the present flood-plain of the stream.

Whitford Valley.

Whitford Valley is a narrow lowland, 2 miles long, situated immediately south-east of Whitford Township. It is occupied by two tributaries of Turanga Creek, the larger of which, Whitford

Stream, flows north from the northern slopes of Puhinui Range, and the other, Valley Stream, follows the course of Whitford Valley and is fed by two streams—Hog Hill Stream and Whyte's Stream—which rise in the elevated Maraetai Hills, 1½ miles to the north-east.

Whitford Stream and its tributaries are confined to the sandstone terrain and generally display the characteristics of streams of such areas. The valley of the main stream is, however, distinctly unsymmetrical, especially in those reaches where its trend is north-east and south-west, for in such cases the south-east walls of the valley have a gentle and regular slope, whilst on the north-west bank there are steep, bush-clad bluffs. These bluffs, in some cases at least, express the presence of comparatively resistant bands of green sandstone interbedded with softer normal Waitemata strata. The appearance of two-cycle topography as a result of the discovery by streams of these bands of green sandstone is a common feature of the western portion of the Whitford-Brookby earth-block.

Hog Hill Stream, and Whyte's Stream further to the south-east, flow south-west in roughly parallel courses three-quarters of a mile apart, and cross the scarp of Clevedon-Waikopua Fault at the border of the Maraetai Hills block by gorges displaying series of picturesque falls and cascades in the greywacke basement. Abrupt reduction in gradient on entering the lower Whitford-Brookby block has caused both streams to build extensive fans of greywacke débris at their debouchure from these gorges, but further downstream the streams have courses of widely different natures. Half a mile from the Maraetai Hills, Whyte's Stream plunges over a 50 ft. face of greywacke, which it has caused to recede some distance, and from this point to Valley Stream shows greywacke continuously in its bed. Hog Hill Stream, however, exposes Waitemata sandstone everywhere in the corresponding section of its course, which, further, is remarkably straight, is roughly graded with respect to the level of Whitford Valley at its confluence with Valley Stream, and lies in a valley of highly unsymmetrical cross-profile, with long, even south-eastern slopes and steep short north-western ones. It is worthy of note that greywacke is revealed in the headwaters of certain of the larger tributaries draining the long south-eastern slopes of the valley of this stream, though the divide appears at higher levels to be wholly Waitemata sandstone. Similar asymmetry is also revealed on a much less prominent scale in Whyte's Stream, and, as previously noted, characterises the Brookby Valleys still further south-east. A section taken across Whitford-Brookby earth-block parallel to and adjacent to the scarp of Clevedon-Waikopua Fault is therefore a series of saw-tooth ridges.

A most interesting case of stream-capture is imminent at the base of Clevedon-Waikopua fault-scarp, where a tributary of Hog Hill Stream (Fig. 26) working along the soft Tertiary sandstone of the lower block has reached a point within 4 chains of Whyte's Stream, which is retained by the greywacke in its bed further downstream at a height of 170 ft. above Hog Hill Stream, half a mile away. At the present time the sandstone divide to be removed before capture of Whyte's Stream by this tributary can be effected does not rise more than 30 ft. above stream level.

Whitford Valley itself presents many interesting features. Its floor is composed of a narrow strip of terraced alluvial deposits which border the south bank of Valley Stream and merge gradually into the long gentle slopes which form the southern margin of the valley. A line of prominent steep, bush-clad bluffs, at the base of which Valley Stream flows in an approximately graded course, forms the northern wall of the valley, so that once more marked asymmetrical conditions prevail. These bluffs range from 100 ft. to 150 ft. in height, and are continuous with the steep north-west slopes of the valley of Hog Hill Stream. Greywacke outcrops in them and along the south-eastern margin of the valley in the vicinity of Whyte's Stream, but elsewhere they are composed entirely of thick beds of Waitemata sandstone.

Two flights of terraces, approximately 20 ft. and 40 ft. respectively above sea-level at the confluence of Whitford and Valley Streams, are well defined throughout the length of Whitford Valley, whilst a third, 5 ft. to 10 ft. above sea-level, appears downstream from this point. These terraces no doubt reflect the changing base-levels instituted by fluctuations of the strand-line in later post-Tertiary times.

Puhinui Stream.

Puhinui Stream rises in the high hills of Tertiary sandstone comprising Puhinui Range, and flows thence in a general westerly direction to Manukau Harbour. Like many other streams of Whitford-Brookby earth-block, the cross-profile of its valley is decidedly unsymmetrical in its upper reaches, for its northern wall is short and abrupt whereas the southern slopes are low and even. Bands of tough calcareous mudstone and gritty sandstone are partly responsible for these steep northern slopes, and have also caused the formation of a series of falls and gorges in a tributary from the vicinity of Frost's Hill.

On leaving the sandstone hills, Puhinui Stream follows a profoundly meandering course in a wide, clearly-defined flood-plain 20 ft. to 30 ft. below the level of the plain-like coastal lowlands, which has been developed with respect to a local base-level instituted by volcanic débris from Wiri Mountain and Matukurua. In its lower reaches the stream skirts these volcanic accumulations and parallels the coast for some distance before entering Manukau Harbour. This suggests that the stream was established before the volcanic outbursts took place.

3. Fault Systems of the District.

Evidence of Tilting and Block-Faulting.

As already indicated, the presence of two systems of faults which trend approximately north-east by south-west and north-west by south-east respectively is clearly demonstrated in the eastern portion of the present area, and has resulted in the existence of at least two well-defined differentially-uplifted earthblocks. (Text Fig. 1). The connection between the major structural features of the eastern margin of the district and those of the Hunua and Wairoa districts further east has been traced by Laws (MS.) and

Bartrum (1927), who have shown that the lowland of Papakura Valley occupies a fault-angle depression between the unmistakable fault-scarp of the Papakura Valley Fault, which forms the south-east face of Brookby Range, and the back-slope of a sharply-tilted block which forms the Hunua Ranges to the south-east. These authors also regard Clevedon-Waikopua Fault of the present paper to be a continuation of their Wairoa Fault, which determines the middle course of Wairoa River, whilst Bartrum (*loc. cit.*) anticipated the view held by the present writer that the abrupt eastern boundary of the Maraetai Hills is also a fault-scarp, developed by a deviated continuation of Papakura Valley Fault which for convenience in description is herein called Lower Wairoa Fault.

The Maraetai Hills Block, bounded roughly east and south-west by Lower Wairoa and Clevedon-Waikopua Faults respectively, repeats the definite north-west tilting of the back-slope of the Hunua Ranges. This is clearly demonstrated in distant views by a long even surface which rises gradually from lowlands at Beachlands, along the crests of the Maraetai Hills, to Trig. Station 1309 (814 ft.) near Clevedon. At closer quarters the tilt is indicated by the persistent north-west dip of basal Waitemata beds at Waikopua, and by the tendency displayed by the south-westward flowing waters of the upper reaches of the Te Puru Stream and the middle reaches of Ruatawhiti Stream to migrate to the north-west.

The valley of this section of the course of Ruatawhiti Stream is of further interest in that at its upper end it opens out into a flat floor with a maximum width of 3 chains. The gradient of the stream at this point is sufficiently steep to suggest that this, as also a similar but narrower feature farther downstream, is merely a flood-plain developed in the course of normal stream degradation, but nevertheless, the deep precipitous nature of the narrows through which the stream crosses the scarp of Lower Wairoa Fault to join Wairoa River indicates the possibility that reduction of gradient, or even ponding, consequent on such a tilt of the block as is here postulated may have had some genetic influence.

In the north-west corner of Maraetai Hills Block there is a very distinct subsidiary down-faulted area known as Kiripaka Basin (Fig. 15), to the north of which lies a correspondingly elevated block—Waihohono Block—which appears to have been titled to the south-west rather than north-west. This is indicated by the prevalent south-west dip of Tertiary sandstone at Omana Beach and Te Puru Estuary at and adjacent to its contact with greywacke that comprises this fragment of the major block.

The extent of the relative uplift of Maraetai Hills Block along Lower Wairoa Fault is certainly not less than 800 ft. near Clevedon, for down-faulted greywacke appears in the bed of Wairoa River at this point. In the vicinity of Duder's Beach, 5 miles north of Clevedon, however, a movement of the order of only 400 ft. is indicated, for Whakakaiwhara, the larger of two masses of greywacke—peaks of the otherwise submerged downthrow block to the east of this fracture—which rise island-like above the Pleistocene and Recent deposits at the mouth of Wairoa River, attains an elevation of 285 ft.,

whereas the maximum elevation of the neighbouring Pukekawa Range of Maraetai Hills is 644 ft.

Along Clevedon-Waikopua Fault the lower or Whitford-Brookby Block has been relatively down-thrown to the south-west to an extent that varies from approximately 200 ft. to 250 ft. at the Waikopua end, to from 350 ft. to 400 ft. at the Clevedon end, adjacent to Trig. Station 1309.

Whitford-Brookby Block is clearly defined along its north-east boundary by the scarp of Clevedon-Waikopua Fault (Fig. 27)), and along part of its south-east boundary by that of Papakura Valley Fault (Fig. 28), but all evidence of other possible bounding fractures has been lost in the subdued faces of the hills of readily eroded Waitemata beds which characterise other marginal areas. Nevertheless it is probable that the south-west continuation of Papakura Valley Fault is responsible for the alignment of the eastern base of Puhinui Range with the scarp-face of Brookby Range, whilst similar evidence suggests that the south-west limits of the block, delineated from the Manurewa district to Wiri by the Great South Road, may have been determined by a north-west continuation of the Papakura-Drury Fault of Laws (MS.). It is of course possible that in the sandstone terrain these fractures may have merged into monoclinal folds, but scarcity of outcrops prevents confirmation of this possibility. Differential uplift, whether by monoclinal folding or by faulting, appears undoubtedly to have occurred, for beds of the Parnell Grit horizon occur at sea-level at Weymouth and yet are uplifted to an elevation of 180 ft. in Puhinui Range near Manurewa. On this interpretation the coastal lowlands facing Manukau Harbour rest on a third, still lower earth-block, a view which is supported by the opinion of Gilbert (1921) that Manukau Harbour occupies a down-faulted area.

Mention has already been made of the alignment of the sudden termination of Brookby Range with the greywacke foothills of Ratahi Range across the mouth of Lower Brookby Valley, and with the abrupt replacement of greywacke by Waitemata strata still further north-west near the crest of Ratahi Range. This alignment may be due to a minor fracture, roughly parallel to Clevedon-Waikopua Fault and dying out in the sandstone terrain to the north-west, but definite proof of this view is not available.

The tilt so clearly manifested in the eastern or Maraetai Hills Block is much less definite in the lower block now described. Nevertheless, observations of the elevations of outcrops of beds of the Parnell Grit horizon, together with the few reliable observations of dip and strike that are available, demonstrate the presence of a broad anticline in the western portion of the block, the axis of which runs roughly from Buckland's Peninsula, through Maungamaungaroa Range to Puhinui Range — approximately parallel to Clevedon-Waikopua Fault—and has a constant plunge to the north-north-west. That this tilt is general throughout the Whitford-Brookby Block is indicated by the fact that practically all streams flowing in an appropriate direction have developed valleys of definitely asymmetrical cross-profile, the steeper slopes of which rise to cuesta-like divides

invariably to the north or north-west, as previously described when dealing with the Brookby Valleys, Whitford Valley, and Puhinui Stream. Such a tilt would also fully explain the origin of the intermontane Upper Brookby Valley as a consequence of the resulting ponding of a section of the course of an ancestral Papakura Stream, and later filling of the basin thus formed by alluvium.

Clevedon-Waikopua Fault (Figs. 26-28).

This fault is represented by a youthful scarp which presents a practically straight and unbroken wall of greywacke trending in a direction 30° west of north from the immediate vicinity of Clevedon Township to a point a short distance south of Waikopua Creek, over 4 miles away, where topographical expression of displacement is soon lost when soft Waitemata strata displace greywacke on the western flanks of the Maraetai Hills. The scarp, if not truly a fault-line scarp, must be classed as a composite fault scarp, as defined by Cotton (1922), for the complete stripping of the Tertiary covering beds of the relatively downthrown block from their basement in Brookby Range indicates that much if not all of its present face has been revealed by erosion. Though stripping of the Tertiary cover from the upper block is far more extensive, yet remnants of it persist at an elevation of 700 ft. near the headwaters of Whyte's Stream.

Small longitudinal streams (Fig. 26) tributary to such strong transverse streams as Hog Hill, Whyte's, and Papakura Stream, follow the greater part of the length of the fault-line, and receive small streamlets which cross the scarp and have developed thereon splendid spur-facets, not uncommonly from 200 ft. to 300 ft. in height, whilst the face of the scarp is everywhere encumbered with greywacke débris in the form of steep alluvial fans and talus deposits.

Several interesting features in addition to those already described during discussion of Whitford Valley and Upper Brookby Valley, are presented by the streams draining the scarp and its vicinity. For example, in the gorge by which it leaves Maraetai Hills Block, Whyte's Stream plunges over a 30-ft. fall, exposing there a clearly defined band of crush-breccia which marks the line of a fracture parallel to Clevedon-Waikopua Fault and shows that the relative displacement of the adjacent earth-blocks has been distributed probably along several parallel faults. Near the debouchure of Papakura Stream into the head of Upper Brookby Valley there is a curious isolated sub-conical hill (Fig. 30), with its south-western face forming part of the scarp of Clevedon-Waikopua Fault; the gorge cut by Papakura Stream near the scarp forms a semicircle about it on the east, whilst it is bounded on the north-west by a steep-walled wind-gap. This interesting wind-gap most probably developed as the scarp was eroded back from the fault-line and continuously beheaded the valley of a small stream flowing north-east to Papakura Stream. Another possibility is that it represents an old course of Papakura Stream across the scarp, but this finds little support in the evidence available.

Several interesting features are connected with a short, vigorous tributary of Totaia Stream which has cut a gorge as much as 100 ft.

in depth along the base of the scarp of Clevedon-Waikopua Fault near its Clevedon limit, and is rapidly working headwards towards Upper Brookby Valley. This stream turns sharply south-west, roughly parallel to Papakura Valley Fault, when but a short distance from the intersection of this fracture with the north-west fault under discussion, and flows in this direction for from half a mile to three-quarters of a mile across a small aggraded basin before again turning sharply to cross the scarp of Papakura Valley Fault in a moderately widely-open valley and emerge on the lowlands of Papakura Valley. The pattern of its course is perhaps explained by splintering of the north-east corner of Whitford-Brookby Block as a result of the intersection of its two powerful bounding fractures, with the consequent production of a shatter-belt which afforded an even easier route for the stream than along the base of Clevedon-Waikopua scarp.

The scarp of Clevedon-Waikopua Fault continues one-quarter of a mile south-east beyond the line of Papakura Valley Fault, and is terminated abruptly in the immediate vicinity of Clevedon by its intersection with Lower Wairoa Fault (Fig. 28), which takes up the differential movement of, and in this locality is roughly parallel to, Papakura Valley Fault. The significance of this off-setting of these powerful north-east fractures will be discussed later, but in the meantime a clearer conception of the relationships of the several earth-blocks and their bounding faults near Clevedon may be obtained from Text-Fig. 4.

Papakura Valley Fault (Fig. 28).

The scarp of this fault is clearly preserved in the straight, steep south-east face of the greywacke hills comprising Brookby Range, which ends abruptly at Ardmore Road and thence runs in an E. 35° N. direction for 3½ miles to the south-east corner of Maraetai Hills Block. The hills immediately behind this sharply-rising and imposing front-slope attain an average elevation 300 ft. higher than the aggraded plain of Papakura Valley, which occupies the fault-angle depression between it and the back-slope of the tilted Hunua Block further south-east (Fig. 31). As already stated, it is possible that Papakura Valley Fault continues south-west along the base of the sandstone hills of Puhinui Range from Alfriston to Manurewa.

Since the relatively downthrown area has been aggraded, the scarp is evidently a true fault-scarp (Blackwelder, 1928, p. 300). It is sub-maturely dissected by numerous short, steeply-graded transverse streams which have cut deep steep-sided notches into the hills and have built extensive piedmont fans of greywacke débris at the base of the scarp. Along the outer edge of the fans there is a swampy strip drained by a sluggish stream which flows north-east roughly parallel to the scarp, and joins Totaia Stream near Clevedon.

At Ardmore and Hunua, across the fault-angle depression of Papakura Valley, Tertiary sandstones cover Mesozoic greywacke similar to that comprising Brookby Range, and dip under the intervening alluvial and swamp deposits which form the floor of the depression (Laws, MS.). From this fact and the disposition of similar Tertiary beds on the western flank of the masses of greywacke which outcrop in the eastern portions of both Maraetai Hills

Block and Whitford-Brookby Block, there is little doubt that prior to faulting a sheet of Tertiary strata continuous with that of the Waitemata area completely covered the present district, and thence extended unbroken in a south-east direction at least as far as the site of the Hunua Ranges.

The extent of the differential movement along Papakura Valley Fault is difficult to estimate. The hills of Brookby Range rise to a maximum height of 450 ft. above the floor of Papakura Valley, and have been stripped of Tertiary covering beds probably several hundred feet in thickness. The depth of post-Tertiary deposit upon the downthrown block is not known but must be fairly considerable, so that on a conservative basis the movement must be in excess of 600 ft. or even 700 ft.

Lower Wairoa Fault (Fig. 28).

Although the major topographical features in the neighbourhood of the mouth of Wairoa River certainly indicate differential movement on a large scale, the orientation of the fractures by which this has been accomplished is indicated only in a general way. The Maraetai Hills are everywhere clearly differentiated from the lowland across which Wairoa River meanders to join Hauraki Gulf, and for at least 2 miles north of Clevedon their eastern bush-clad face undoubtedly represents a maturely dissected fault-line scarp trending north-north-west. North of this section, however, clear demonstration of a scarp is obscured by far-reaching erosion, and continuation of the fault is suggested only by the sub-meridional alignment of spur ends which project on the lowlands bordering Wairoa River. The relief here is much less than that near Clevedon, and the subdued lower slopes of the face of the hills grade into extensive, low-angle, confluent fans which themselves merge into the lowlands.

It is possible that the remarkably straight middle reaches of Ruatawhiti Stream may reflect the direction of major fracturing in this locality. Such a feature is so unusual in the Maraetai Hills as immediately to suggest as its cause the presence of a fracture or shatter-belt apparently orientated in a direction roughly the mean of those determining the eastern limits of the elevated block from Clevedon to Duder's Beach.

For 1½ miles north of Duder's Beach, greywacke cliffs 40 ft. to 50 ft. high form a remarkably straight shoreline which is suggestive of faulting, though it must be admitted that the features presented could equally well be explained by wave-erosion. The streams in the hills immediately to the west, however, show a marked tendency to flow parallel to this coast in a south-south-west direction and to develop, along with others at right angles, a trellised drainage-pattern which is paralleled by the headwaters of Te Puru Stream still further west. This suggests the presence of N.N.W.-S.S.E. and possibly E.N.E.-W.S.W. fractures or shatter-belts—fold structures in the "incompetent" greywacke can safely be ignored in this case—and lends support to the classification of this length of coast as a fault coast.

It therefore appears probable that the whole of the eastern boundary of Maraetai Hills Block is determined by a fault or series of faults, here called Lower Wairoa Fault, which, bending continuously more and more to the west as it is followed north, trends north-north-east near Clevedon and north-north-west beyond Duder's Beach. This is quite in accord with what Henderson (1929) considers to be the usual condition in the case of major faults.

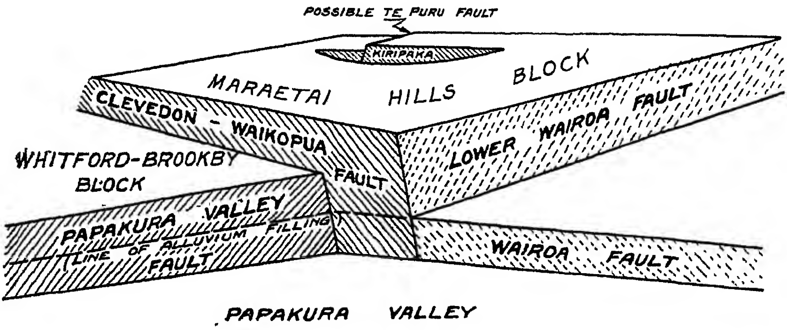

Fig. 4.—Block-diagram to illustrate the relationship of the several earth-blocks and their bounding fractures in the vicinity of Clevedon Township.

The significance of the one-quarter of a mile off-set of the sub-parallel scarps of Papakura Valley and Lower Wairoa Faults along Clevedon-Waikopua Fault deserves some consideration. The relationship of the several fractures and of the earthblocks determined by them is, as far as can be seen, as shown diagrammatically in Text Fig. 4. It is highly probable that the four faults shown are not independent, and that in reality only two fractures exist. The first trends north-west and includes Clevedon-Waikopua Fault and Wairoa Fault of Laws (MS.), the latter continuing the course of the former across Papakura depression into the middle section of the course of Wairoa River. The second major fracture is a flatly-curved one, concave to the north-west, and trends on the average north-east by south-west. It is represented by Papakura Valley and Lower Wairoa Faults. This view is supported by the fact that Laws' estimate of a downthrow of 400 ft. to the south-west along Wairoa Fault agrees with that indicated at the Clevedon end of Clevedon-Waikopua Fault, whilst a downthrow of the order of 800 ft. to the south-east along Lower Wairoa Fault, which is suggested near Clevedon, compares well with a corresponding movement of at least 600 ft. or 700 ft., and probably much more, which has been deduced for Papakura Valley Fault. If this interpretation of the fault systems is correct, in order to explain the off-setting that has been noted, it is necessary to postulate that the north-east by south-west fracture originated first, and that its scarp was later displaced by movement along the more recent north-west fracture. Support for this is forthcoming in that youthful features characterise the

scarp of Clevedon-Waikopua Fault, whereas the scarps of Papakura Valley and Lower Wairoa Faults are sub-maturely or even maturely dissected.

Kiripaka Basin and Waihohono Block.

These two interesting topographical features of the north-western portion of the Maraetai Hills area form respectively the downthrow and upthrow members of a fault, here called Kiripaka Fault (Fig. 32), which trends 30° north of west and is traceable by a well-displayed scarp which begins at a point one-half mile east of Maraetai-Whitford Road, and continues for nearly a mile eastward. Kiripaka Basin itself is bounded on the north-east by this scarp, but its other limits are less clearly defined, though they suggest that the key to the structure of this area is differential down-warping relieved in the north-east by fracture.

The floor of Kiripaka Basin (Fig. 15) rises in a gentle, regular slope to the south until it gains the divide north of Bloomfield's Stream, Waikopua, and there culminates at what is probably the axis of warping. At its eastern margin it merges into rather abruptly rising high hills of greywacke, without, however, definite topographic signs of fracturing, whilst its western limit is defined by a subdued ridge of Tertiary sandstone which is followed by Maraetai-Whitford road. Tertiary sandstone outcrops extensively beneath the upper western slopes of the floor of the basin and in isolated outliers further east, but for the most part it has been entirely stripped from the underlying greywacke basement. The streams that cross the floor apparently were originally consequent upon the surface of the sandstone cover, and have later been superposed upon the older greywacke.

The central section of the scarp of Kiripaka Fault is followed at its base by the middle reaches of Te Puru Stream, and exhibits splendid spur-facets, some as much as 100 ft. high, marked off by short, hanging streams (Fig. 32), whilst it further displays two sharp displacements to the north, one 3 chains and the other 1 chain in depth. Both north-west and south-east of this, true scarp features rapidly disappear, and the impression is given that displacement gradually dies out in these directions. To the north-west additional grounds for this belief are afforded by an abrupt uplift of the greywacke floor of this corner of the basin, as a result of which Te Puru Stream has been compelled to turn abruptly to the south, and to cut a deep outlet-gorge across the line of the scarp. As this outlet was lowered, there were pauses of sufficient length to allow the stream to carve three terraces in the greywacke of the lower portions of the floor of the basin. The highest of these is a broad bench about 100 ft. above sea-level; 20 ft. below this there is a narrower bench as much as 6 chains wide, and again 30 ft. below this, adjacent to the stream, there is another terrace carved in greywacke crush-breccia.

Waihohono Block, on the north of Kiripaka Basin, is bordered on three sides by Te Puru Stream and has a most striking trellised drainage-pattern incised on its surface; the streams flow in remark-

ably straight courses in one or other of two directions approximately normal one to the other—either roughly meridional, as in the case of the upper and lower reaches of Te Puru Stream itself, or else parallel with the scarp of Kiripaka Fault. This suggests that the stresses associated with the downfaulting and downwarping of Kiripaka Basin were in a measure relieved by minor fractures in Waihohono Block, and that, in addition to controlling the courses of the streams draining this area, these also imparted to the block a slight tilt to the south-west. Direct evidence of such minor faulting is indeed present in the north-east corner of the block, for a low scarp of greywacke, 5 ft. high, there forms the western edge of a long low reef at Maraetai Point, and has been exposed as a result of the removal by wave-erosion of overlying soft Pleistocene beds from its westwards dipping surface (Fig. 33). Along the base of the scarp there is a band of completely crushed and slickensided greywacke which trends 10° east of north and is closely aligned with the straight upper portion of Te Puru Valley.

In support of the contention that the Waihohono Block is a relatively uplifted unit, it should be mentioned that the general level of the hills west of it is very decidedly below that of its surface, whilst a mass of greatly-crushed greywacke with elongated lenticles of uncrushed rock that is exposed in a quarry on the western bank of Te Puru Stream, one-quarter of a mile above its mouth, appears to represent friction-breccia produced by the fault that is believed to form the western boundary of the block.

There is a possibility that Te Puru Stream originally drained from Kiripaka Basin across a low col in the divide followed by Maraetai-Whitford Road, maintaining the direction of Kiripaka Fault, and finally entered Hauraki Gulf south of Beachlands. If this be so, its present course may be explained as the result of capture of the earlier stream by another working south along the zone of crushing or fracture that determines the western limits of Waihohono Block. At the present time, however, the hypothetical elbow of capture is at an altitude at least 130 ft. below that of the col mentioned, whilst this latter shows no clear evidence of earlier occupation by a stream, so that this hypothesis cannot be extended beyond the realms of conjecture.

Resumé of the Geological History of the District.

During Trias-Jura times a great geosyncline occupied the greater part of New Zealand, and in it were deposited enormously thick sediments, now represented by Hokonui (Trias-Jura) strata, derived from a land-mass of which the exact location is not known, but which, on the evidence of the greywackes of the mid-Auckland district, was largely composed of crystalline rocks.

This long period of deposition was brought to a close by an orogenic period in early Cretaceous times, as a result of which the sediments in the Mesozoic New Zealand geosyncline were thrown into a series of sharp folds and suffered great erosion prior to en-

suing submergence in the late Cretaceous, when beds of the Onerahi Series were deposited throughout North Auckland and possibly in the present district as well. However, as a result of erosion following a late Cretaceous or early Tertiary orogenic movement which closed the Onerahi transgression, such Cretaceous beds, if present, were completely stripped from the underlying basement of Hokonui strata in North-West Manukau, so that, in a subsequent submergence in Miocene times, Waitemata strata were here deposited directly on Hokonui greywacke..

During the Waitemata transgression, rivers from a land which appears to have been situated north-west of Auckland City (Turner and Bartrum, 1929) built an extensive delta on the gradually subsiding floor of the shallow Waitemata sea, and this finally extended to and ultimately completely covered Hokonui strata which now form the Maraetai Hills, where, in the early stages of submergence, sufficiently sheltered conditions held in certain localities to enable the formation of impure limestones such as those now seen at Waikopua. Further, during the deposition of Waitemata strata, a number of small andesitic vents more or less simultaneously broke through the floor of the Waitemata sea and gave rise to the volcanic tuffs of the Parnell Grit horizon.

In early Pliocene times differential uplifts of the Kaikoura orogeny of Cotton (1916) caused the cessation of deposition of the beds of Waitemata Series, and great fractures, oriented in two series, one roughly at right angles to the other and trending approximately north-west by south-east and north-east by south-west respectively, gave rise in the present district to two distinct elevated earth-blocks, both of which display a definite tilt in an approximately north-west direction.

This uplift resulted in such great erosion of the Tertiary covering-beds that in some districts the underlying Hokonui greywacke became exposed over large areas. It was followed by a movement, generally of uplift but broken by several periods of standstill and by at least one minor positive movement, which continued till comparatively recent times, when a sharp positive movement caused extensive flooding of deep, youthful valleys cut during the preceding uplift, and thus initiated the embayed coastline of the vicinity of Auckland City and the present erosion cycle.

At some period of sub-Recent times commencing probably prior to this final submergence, volcanic activity which resulted in the building of tuff and scoria cones and the outpouring of basaltic lavas broke out in the western portions of the district and continued into comparatively Recent times.

The complicated history sketched above was brought to a close by a slight uplift of a few feet after the establishment of the cycle of erosion to which the modern topographic forms are due, but its effects away from the coast-line are almost inappreciable.

FORAMINIFERA FROM WAIKOPUA AND THE PARNELL GRIT HORIZON.

Identifications by Mr. W. J. Parr, Caulfield, Victoria, Australia, are listed below.

Mr. Parr states that the most characteristic foraminifera in the samples supplied were the *Amphisteginae, Lepidocyclinae* and *Miogypsinae,* and that a thick-domed species of *Amphistegina* with affinities to *A. lessoni* d'Orb, was common in all of them. A species of *Lepidocyclina* (sub-genus *Nephrolepidina*) from Whitford Stream is described as new to New Zealand, whilst *Cristellaria* (now *Lenticulina*) *mamilligera* has not been recorded from New Zealand Tertiary since Karrer described it in 1859. *Siphonia australis* has recently been described from the older Tertiary of Victoria.

Several of the species represented are probably new.

The numbers to the columns below refer to the following localities:—

1. *Bloomfield's Stream, Waikopua.* From base of green sandstone above upper limestone, north bank.
2. *Bloomfield's Stream, Waikopua.* From green sandstone below upper limestone, south bank.
3. *South Branch, Waikopua.* From base of green sandstone over the limestone, south bank.
4. *South Branch, Waikopua.* From boulder of limestone in bed of stream.
5. *Granger's Stream, Whitford.* At limit of tidal waters. Specimen intermediate between Parnell Grit and Turanga Greensand facies.
6. *Granger's Stream, Whitford.* 100 yards up-stream from 5. Turanga Greensand facies.
7. *Whitford Stream.* ¾ mile north-east of Trig .28. Turanga Greensand facies.
8. *Whitford Stream.* Headwaters of western tributaries. Turanga Greensand facies.
9. *Maungamaungaroa Creek.* East bank, ¾ mile up-stream from road bridge. Turanga Greensand facies.

In the following lists *f* indicates fairly common, *c* common, and *vc* very common.

	1	2	3	4	5	6	7	8	9
Ammodiscus sp.		x							
Placopsilina cenomana d'Orb.		x							
Textularia gibbosa d'Orb (Short var.)		x	f	x	x		x		f
" *goesii* Cushman			x		f				
" *rugosa* (Reuss)			x	x					f
" sp. aff. *trochus* d'Orb.							x		
" sp. aff. *catenata* Cushman					f				
" *sagittula* Defr. (long var.)	x		x	x	x				
" sp. aff. *carinata* d'Orb.					c				
" *gramen* d'Orb.		x	x		x		x		
Gaudryina triangularis Cushman									x
" *quadrangularis* Bagg			x		f				
" *pupoides* d'Orb.					f				
" *reussi* Stache			x		x				x
" sp. with excavated sutures				x					
" sp. (elongate, sharp angled)			x		c		f		
Clavulina communis d'Orb.					x				
" *antipodum* Stache	x		f		x		f		f
Quinqueloculina lamarckiana d'Orb.					?		x		
Lenticulina gyroscalprum (Stache)					x		?	x	x
" *duracina* (Stache)							x		
" *orbicularis* (d'Orb.)					?				
" *mamilligera* (Karrer)						x	x		
" *gibba* (d'Orb.)						x			
" sp. aff. *crepidula* (F. & M.)							x		
" *schloenbachi* (Reuss)					x				
" sp.					x				x

	1	2	3	4	5	6	7	8	9
Nodosaria (*Dentalina*) *obliqua* Linné							x		
" " sp. aff. *obliqua* (Linné)					x				
" " *consobrina* (d'Orb.)				x	x				
" " *consobrina* var.									
" " *emaciata* Reuss									x
" " *soluta* (Reuss)							x		
Nodosaria radicula (Linné), slender var.					x				
" *scalaris* (Batsch)					f				
Vaginulina legumen (Linné)			x		f				
Lagena orbignyana (Seguenza)					x				
Guttulina communis d'Orb.					x		x		
" *problema* d'Orb.									x
Polymorphina sp.					x				
Sigmoidella elegantissima (Parker and Jones)					x				x
Nonion depressulus (W. & J.)									x
" *scapha* (F. & M.)			x		x				
" *umbilicatulus* (Montague)					x				
Dimorphina striata (Schwager)					c		x		x
Elphidium macellus (Fichtel & Moll.)					x				
" *craticulatus* (F. & M.)	x				x				
Bulimina affinis d'Orb.						x			
Bolivina robusta Brady					f				
" sp. aff. *textilarioides* Reuss	x								
Uvigerina sp. aff. *pygmaea* d'Orb.	x				x				
" *schwageri* Brady					x				
Discorbis bertheloti d'Orb. (var. *complanata* Sidebottom)					x				
" *bertheloti* (d'Orb.) var.					x				
Discorbis (?) sp.					f				
Gyroidina soldani d'Orb.					x				
Eponides repandus (F. & M.)		x		x	f				
" (?) sp.				x			x		x
Rotalia clathrata Brady									x
" sp. nov. (1) (aff. *clathrata*)			x		c				
" sp. nov. (2) (aff. *calcar.* d'Orb.)				f	x		f		x
" sp. nov. (3) (domed form, aff. *clathrata*)				f	x	x	c		c
" sp.	x								
Epistomina elegans (d'Orb.)							x		
Siphonina australis Cushman					f				
Amphistegina sp. aff. *lessoni* d'Orb.	x	c	c	c	f	vc	c		c
" *hauerina* d'Orb.			x	x		x		x	x
Calcarina sp. aff. *calcar* d'Orb.							x		
Cassidulina subglobosa Brady		x							
" *crassa* d'Orb.					?				
" sp. nov. aff. *pacifica*; Cushman & *subglobosa* Brady					f				
Ehrinbergina mestayeri Cushman					x				
Globigerina bulloides d'Orb.		x	f		x				
" sp. aff. *inflata* d'Orb.					x				
" probably sp. nov.	c	x	f		c				
Cibicides refulgens Montfort	f	x		x	x				
" sp. between *refulgens* and *ungerianus* (d'Orb.)	f	x	x						x
" *ungerianus* (d'Orb.)					x		x		
" *tenuimargo* (Brady)					x				
" sp.	x				f				
Gypsina globulus (Reuss)					x				
Carpentaria proteiformis Goes							x		x
Lepidocyclina (*Nephrolepidina*) sp.								x	
Miogypsina irregularis (Mich.)							x		

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The New Zealand Double-crested Shags; With Description of a New Species.

By W. R. B. Oliver, M.Sc., F.N.Z.Inst.
Director, Dominion Museum, Wellington.

[*Issued separately, 29th May, 1930.*]

Plate 24.

The Double-crested Shags of New Zealand differ from all the other species of shags in the same region in their very slender bill, the height being nearly the same throughout, and in the assumption of two median crests in the breeding plumage. They are further distinguished by the grey under-surface. Bonaparte, in 1855, founded the genus *Stictocarbo* with Sparrman's *Pelecanus punctatus* as type. In other parts of the Pacific species of shags are found with similar slender bills. A South American species, *Phalacrocorax gaimardi*, has the under-surface grey, like the New Zealand species, but no crests have been recorded for it. In the North Pacific are three species (*P. urile, P. pelagicus, P. perspecillatus*) with slender bills and two crests, but the plumage generally is greenish-black. Perhaps these four species are really related and should be referred to the genus *Stictocarbo*. The New Zealand members of this genus differ from the other shags in some of their habits, for instance, they feed largely on crustacea, and utter whistling notes.

Hitherto only two species of Double-crested or Spotted Shags have been recognised in the New Zealand region, *S. punctatus* in the main islands and *S. featherstoni* in the Chatham Group. Now, through the investigations of Mr. Edgar F. Stead, of Christchurch, a third species has been discovered. Though this shag has been considered to be distinct from the Spotted Shag for some time by some of the residents of Stewart Island, where it is known as the Blue Shag, and a specimen was collected some years ago by Mr. H. H. Travers and passed with his collection to the Dominion Museum, the credit of recognising it as an undescribed species belongs to Mr. Stead, who, in December, 1929, spent a month on the islands to the west of Stewart Island and procured two specimens. Mr. Stead's specimens were adults in non-breeding plumage, Travers's specimen is in breeding plumage. Mr. Stead has been generous enough to forward me for description his two specimens. His observational work over the past twenty-five years has added much to our knowledge of the birds of New Zealand and I do not think I could choose a more fitting title for the new species than one founded on the name of this ornithologist. It will serve, too, as a deserving compliment to one who has played no small part in bringing the bird protection law to its present efficient state.

The genus *Stictocarbo* now includes within the New Zealand area three species which may thus be distinguished:

Stictocarbo punctatus.

Stictocarbo steadi.

Face p. 138.

White band over eye and down side of neck:
Broad behind eyes .... *S. punctatus*
Narrow behind eyes .... *S. steadi*
No white stripe on side of head and neck .... *S. featherstoni*

1. **S. punctatus**—Spotted Shag.

Pelecanus punctatus Sparrman, Mus. Carls. fasc. 1, No. 10, 1786, Queen Charlotte Sound.

Distinguished from *S. featherstoni* by the presence of a white stripe on the side of the head and neck; and from *S. steadi* by its much lighter upper surface and broader white stripe on the side of the head produced forwards as far as the bill.

Distribution.—North and South Islands as far south as Banks Peninsula, but discontinuous in its distribution. It is, or was, most common in Hauraki Gulf, Hawkes Bay, Cook Strait, and Banks Peninsula.

2. **S. steadi**—n. sp. Blue Shag.

Differs from *S. punctatus* in the white stripe on the side of the head and neck, being narrow throughout, and not advancing in front of the eye, and the upper-surface being dark greyish-brown instead of light brownish-grey.

Adult male in breeding plumage.—The feathers of the forehead and occiput elongated, forming two crests. Long white filoplumes on back of neck, shorter ones on foreneck, mantle and flanks. Top of head, crests, back of neck and mantle black glossed with greenish-blue, the crest feathers brownish-grey at the base. On each side of the head a narrow white stripe begins over the eye and passes backward but distant from the occipital crest and continues down the sides of the neck to the shoulder. Upper back, scapulars and wing coverts dark greyish-brown, each feather with a black spot at the tip. Lower back, rump, upper-tail coverts, flanks, lower abdomen and under-tail coverts dark greenish-blue; quills dark brown; tail black. Sides of head, throat and foreneck sooty black glossed with green; breast and abdomen grey. Length 71, bill 6.3, wing 26, tail 11.5, tarsus 5.5 cm. (Type specimen from Otago, in Dominion Museum, Wellington).

Adult male in non-breeding plumage.—The crests are absent, also the large filoplumes, though small ones are present on the neck and flanks. The white stripes on the sides of the head are mottled with black. Remainder of plumage as in summer. "Bare skin on cheeks and throat sea green. Pimples near eye verdigris green (vivid). Feet lemon yellow with dark brown knuckles." (Stead). (Specimen from S.W. of Stewart Island, 20th Nov., 1929, in Stead Collection).

Distribution.—Stewart Island; Otago. The northern limit of this species has yet to be determined.

3. **S. featherstoni**—Pitt Island Shag.

Phalacrocorax featherstoni Buller, Ibis, 1873, p. 90.

Distinguished from both *S. punctatus* and *S. steadi* by the absence of a white stripe on the side of the head and neck.

Distribution.—Chatham Islands. Almost restricted to Pitt Island and the off-lying islets.

Atlantobellerophon, a New Gasteropod from the Rhaetic of New Zealand.

By C. T. Trechmann, D.Sc., F.G.S.,
Castle Eden, Co. Durham, England.

[*Issued separately, 29th May, 1930.*]

Plate 25.

Under the name *Atlantobellerophon Zealandicus* I propose to record the occurrence of a unique Bellerophon-like presumably Heteropod mollusc from the Upper Trias or Rhaetic of New Zealand.

The specimen is an indifferently preserved cast in a matrix of coarse greenish almost conglomeratic greywacke or Felspathic sandstone. The rock contains in addition several specimens of the Spirigerid Brachiopod *Clavigera* (or *Hectoria*).

Atlantobellerophon Zealandicus gen. et sp. nov. Fig. 1.

Description.—Shell of large size, has apparently been coiled in a flat plane but the early whorl is now rather twisted and distorted by movements in the rock. Whether the apex or protoconch was at all unsymmetrically placed cannot now be seen. The shell seems to have been everywhere very thin but no trace of it remains owing to its having been completely dissolved away, though the test of one of the Brachiopoda in the same mass is still partially preserved. No trace of early whorls nor of the young shell is visible; the first part of the body chamber is bent in a semicircular curve, the sides are flattened or gently rounded, the dorsum is well rounded.

The inner surface slopes gently down to the umbilical depression which appears to have been small and fairly deep but is now filled up with matrix. Towards the aperture the shell tends to uncoil and straighten out and to detach itself from the earlier whorl and rapidly widens out forming a flaring aperture.

The dorsal surface carries a slightly raised scar with a shallow groove on either side representing a slit that has been filled up as the shell grew, measuring 5 or 6 mm. in width. This slit band gradually becomes higher and more prominent as it passes towards the aperture, near which it seems to have become a slightly raised crest or ridge rather like that of *Atlanta.*

At the aperture the rim of the left-side of the shell, the only side preserved, has the appearance of a broad and wide flap of curved outline bent slightly outwards towards the umbilical side and very deeply cut down on the dorsum where a deep triangular gradually narrowing slit occurs till it meets the filled in slit band or ridge. No trace of surface decoration can be seen so the shell may have been smooth as well as very thin. There are irregularites on the surface which may in places represent growth-lines but most of them are due to accidents of fossilization in the coarse matrix. The

Photograph of specimen of *Atlantobellerophon Zealandicus* gen. et sp. nov. About two-thirds natural size. Dorsolateral view.

From the Rhaetic of Eighty-eight Valley, Nelson, New Zealand. At X is a specimen of *Clavigera* (*Hectoria*) *bisulcata*.

right side of the specimen is damaged and obscured and the early part seems to have been crushed in.

Dimensions.—Length 117 mm., width 78 mm., thickness of early whorl 36 mm., width of aperture about 84 mm.

Horizon and Locality.—Locality 197 of the early New Zealand Geological Survey collections. Spiriferina beds, Eighty-eight Valley, Waimea County, Nelson, South Island, New Zealand. "Lias or Rhaetic," collected many years ago by Mr. A. McKay.

The Brachiopods in the matrix of the specimen appear to be *Clavigera* (*Hectoria*) *bisulcata** Hector sp. MS. I ventured to rename the genus *Clavigera* and call it *Hectoria* a few years ago but it seems to me better now to retain the old name *Clavigera* as later

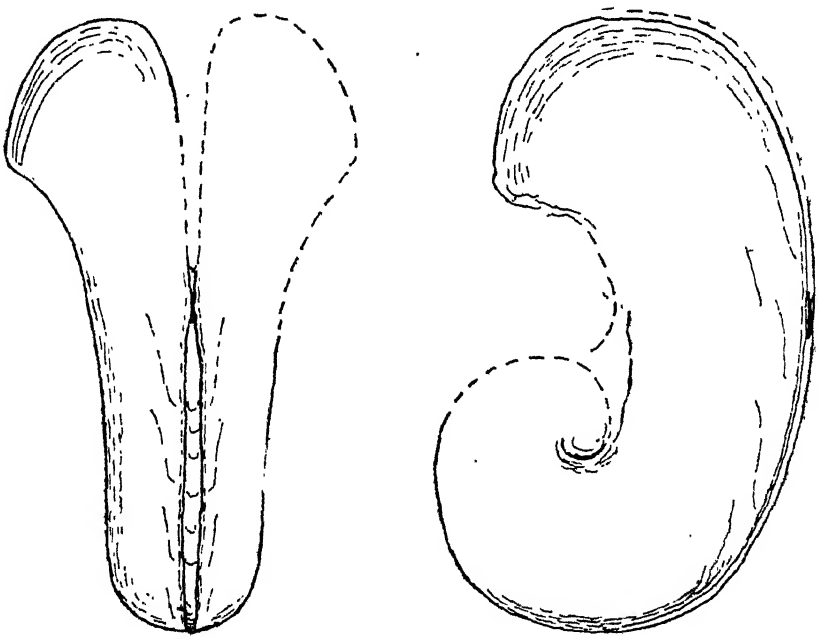


FIG. 1.—*Atlantobellerophon Zealandicus* gen et sp. nov. Rhaetic, Eighty-eight Valley, Nelson, New Zealand. Attempted restoration, dorsal and lateral view × ⅔.

writers have done. McKay notes this locality as Lias or Rhaetic but to me the matrix resembles more that of the Trias than the Lias. The *Clavigera* in it is more like the Rhaetic *C. bisulcata*, very common in the higher beds at Nugget Point, than the smaller and more slender *C. cuneiformis* Trechm. which occurs in the Jurassic. It is questionable whether *C. bisulcata* occurs in the Carnic or Noric.

*Trechmann. Trias of New Zealand. *Q.J.G.S.* vol. 73, pt. 3, 1918, p. 235, Pl. 25, Figs. 1a and b; O. Wilckens: Contrib. to Pal. of N.Z. Trias. *N.Z. Geol. Survey, Pal. Bulletin*, No. 12, 1927, p. 31, Pl. 6, Figs. 6, 7 and 8a and b.

The so-called Rhaetic of New Zealand appertains rather to the Trias than to the Jurassic series of beds.

Affinities.—Whether the extinct Bellerophontidae are in any way related to the living genus *Atlanta* is a matter that may never be settled. *Atlanta,* though a very small shell, is wound in a flat spiral with the protoconch projecting obliquely on the left side; the last whorl has a high and sharp median keel which becomes a deep slit towards the mouth. The present New Zealand fossil has a very thin shell, a deep slit like that of *Atlanta* and a slit band which seems to have turned into a sharp keel towards the aperture rather like the keel of *Atlanta.* As it seems to be a new genus perhaps the name *Atlantobellerophon* though cumberous may not be inappropriate.

Discussion of Allied Fossil Forms.

Tremanotus maideni Etheridge.* Fig. 2.

A curious and unique somewhat analogous shell is recorded from the Hawksbury sandstone of Australia. It is another of the very rare, presumably pelagic molluscs of the Mesozoic. It is quite different, however, from the New Zealand Rhaetic form. Sir T. W. E. David, F.R.S., referring to the *Tremanotus* says "this Silurian genus on a Triassic horizon may represent either a remarkable survival, or it is possible that the fossil may be an erratic in this formation." The following is a description of the species copied from the original report:—

Shell discoidal, strongly trumpet-shaped, thin, whorls five or more, visible on both sides, elliptical in section, the last one subangular at the sides, but the inner whorls with the flanks much more rounded; apertural expansion much prolonged upwards, but not greatly expanded laterally; the anterior and outer lip reflected backwards, and the slit if present not visible from the imperfection of preservation; inner lip apparently not much reflected, siphonal openings numerous, close together, oval and situated on rather raised, oblong prominences which give to the periphery a rather broken keeled appearance; surface of shell ornamented with spiral fluctuating lines parallel to the dorsal keel, which on the expanded outer lip becomes coarser and more plait-like. Length 4 inches, breadth 2 inches. This unique shell is quite distinct from either of the Gotland species, but is nearer to *T. alpheus* Hall or *T. angusta* Hall as figured by Billings, agreeing with the former especially in the broad plait-like ribbing on the back of the outer lip and the apparent absence of much lateral expansion of the same.

Locality.—The new Government Docks, Biloela, Sydney; Hawkesbury Sandstone, at a depth of 25 feet from the surface. The fossil is surrounded by a matrix of Limonite, such as arises from decay of organic matter.

**Mem. Geol. Surv. New South Wales,* Palaeont. No. 1, 1888, pp. 15-18; *Ann. Rep. Dep. Mines New South Wales* for 1886 (1887) pp. 174-6, Figs. 1-3; Sir T. W. E. David, F.R.S., *Brit. Assoc. Handb. Australia,* 1914, p. 276.

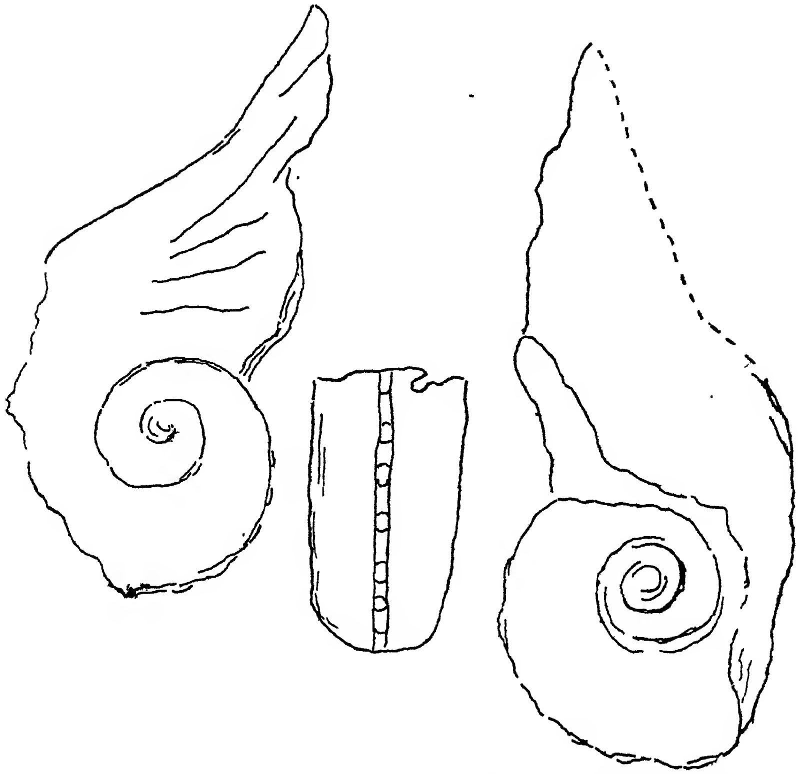


FIG. 2.—*Tremanotus maideni* Etheridge, Hawkesbury Sandstone, Sydney, Australia. A sketch of the original figure.

Bellerophon peregrinus Laube*

This is a small species more resembling the Palaeozoic Bellerophons and comes from the Lower Trias, lower than the well-known St. Cassian Fauna. It is said to be globose, with a dilated aperture a wide and large fissure and a closed narrow umbilicus.

Bellerophon dilatatus † Sowerby.

This large species comes from the Lower Ludlow formation, Upper Silurian; the shell is discoid, smooth, with widely umbilicated sides, the aperture is suddenly dilated and is represented as complete or orbicular in outline.

Bucania cornuarietis J. de C. Sowerby.

Bucania was established by Professor J. Hall, of Albany, to include several species of shells of a peculiar form usually referred to *Bellerophon* but differing from them in having all the volutions visible and gradually increasing in size. *Bellerophon cornuarietis* of the Carboniferous Limestone of England will fall into this group.

**Fauna der Schichten von St. Cassin.* 1865, p. 64, Pl. 28, Figs. 11-12.
†Murchison *Silurian System,* 1839, p. 627, Pl. 12, Fig. 23.

Notes on New Zealand Mollusca. No. 5.

By Marjorie K. Mestayer.

[*Issued separately, 29th May, 1930.*]

Plate 26.

The novelty described below was lent to me by Captain Bollons several years ago. It was referred to the late Mr. C. Hedley, who stated that it was quite new to him. Some time back I had occasion to study it very closely and came to the conclusion that it was an unknown species.

The accompanying figures were drawn by Miss J. K. Allan, and are beautiful and accurate figures of a specimen which is just about the diameter of a threepenny piece. I wish to thank her heartily for her careful work. At the same time, I wish to draw a little attention to all that New Zealand conchological workers owe to the late Captain J. Bollons. He was a most untiring collector, and extremely generous with specimens and any information which he could supply. Even a casual look through the Manual of the New Zealand Mollusca will show how deeply the late Mr. Suter was indebted to him. His recent death is a great loss to New Zealand conchology, as well as to his many friends.

The following species is founded on a specimen he valued; yet, when I told him I considered it undescribed, he generously gave me his only specimen, knowing that I wished it to bear his name. Since then I came to the conclusion that it had better be placed in a new genus, and Dr. J. Marwick concurred in this opinion as neither this nor the other species dealt with in this short paper seemed to fit properly into existing genera. For the present they can remain in the Family Architectonicidae, but they differ widely from other New Zealand members of the family, and it may prove advisable to set up a new family for these depressed species.

Family ARCHITECTONICIDAE.

Mangonuia n. gen.

Type *Mangonuia Bollonsi* n. sp.

Generic characters.—Shell small, discoidal, coiled in one plane. Apex slightly depressed. Under-surface concave, nucleus clearly visible. Whorls angular, slightly oblique, with concentric marginal threads. Aperture quadrangular. Spiral and radial sculpture. Nucleus smooth, rounded, sharply defined, slightly tilted. Another member of this genus is *Omalaxis meridionalis* Hedley, Australia.

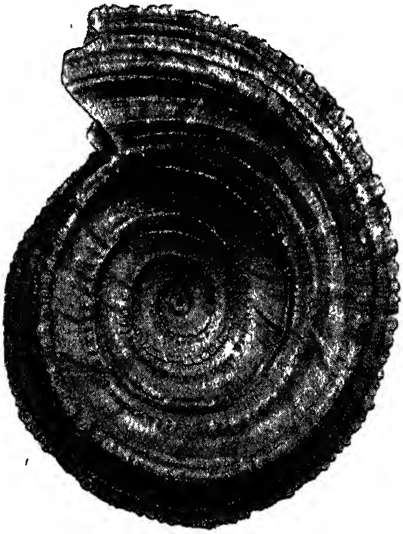


Fig. 1. Under surface.

Holotype.

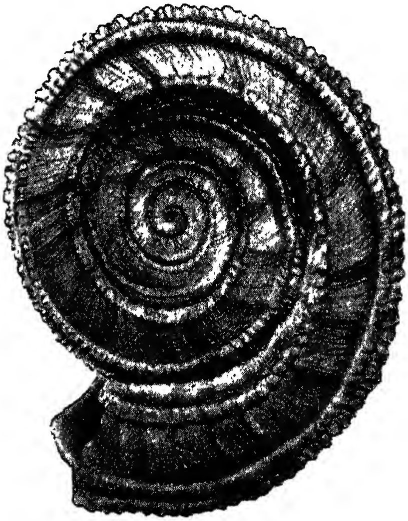


Fig. 2. Upper surface.

Mangonuia Bollonsi.

Fig. 3. *Mangonuia Bollonsi.* Side view.

Mangonuia Bollonsi n. sp. Pl. 26 Figs. 1-3.

Shell discoidal, coiled in one plane, upper surface flattened, apex very slightly depressed. Under-surface concave, widely open.

Protoconch, minute, slightly tilted about 2 whorls smooth, rounded, the adult sculpture starting from a slight varix.

Whorls 4, quadrangular, the two peripheral angles granosely carinate, periphery oblique.

Sculpture, on the upper peripheral angle are two granular spiral threads, the outer much the stronger, and with five or six fine spiral striae on its under edge. On the inner edge is a single granular thread, then a tiny slope, with some spiral striae on it, to the suture. On the last half whorl the suture is clearly marked.

The whole shell is covered with extremely fine spiral striae, only visible under a strong hand-lens; they are overlaid by much stronger radial growth-lines, which are unequal in strength and spacing. On the peripheral angle are two well-marked spiral threads, one near each edge; base with a granular carina on both outer and inner edge, with a slight almost vertical drop to the suture.

Colour, pale biscuit tint.

Aperture, quadrangular externally, internally rounded. Imperfect on the holotype, about 4 mm. having been broken off.

Measurements.—Major diameter, 16.5 mm. Minor diameter, 13 mm. Height, 5 mm.

Locality.—Off North Cape, New Zealand. Depth, about 75 fms.

Material.—Holotype and one imperfect juvenile in my collection.

Remarks.—The juvenile is the specimen that on Mr. C. Hedley's identification I recorded as *Discohelix meridionalis* Hedley, *Trans. N.Z. Inst.*, vol. 48, p. 125, 1915, which species is closely allied to *Mangonuia Bollonsi*, but has 3 peripheral threads, and the beaded row on the inner margin of both upper and under surface is more marginal than in *M. Bollonsi*. As stated above I consider them as congeneric. The holotype and juvenile paratype were dredged by the late Captain Bollons off the coast of Mangonui County.

AWARUA n. gen.

Type *Omalaxis amoena* Mur. & Suter.

Suter *Man. N.Z. Moll.*, 1913, p. 318, Pl. 15, Fig. 21, a. b.

In A Commentary on Suter's Manual of The N.Z. Mollusca, *Trans. N.Z. Inst.*, vol. 47, p. 461, Iredale states that the genus *Omalaxis* must be eliminated, and transfers *Omalaxis amoena* M. & S. to *Heliacus*. Now the type of *Heliacus* is *Solarium herberti* Desh., which Tryon, in Man. Conch. (1) 9, pp. 17-18, Pl. 5, Fig. 82, makes a synonym of *Torinia cylindrica* Gmelin, a shell entirely different from *O. amoena*. It is conical, has more rounded whorls and a very different aperture. *O. amoena* is very depressed, has a wide, open umbilicus, with the protoconch plainly visible. I therefore name it as type of *Awarua* n. gen.

Generic characters.—Shell very depressed, apex flat. Protoconch minute, smooth, the extreme tip hyaline, visible from below. Whorls keeled, very slightly descending, lightly rounded; sculpture spiral and radial.

The generic name is that of the vessel from which the holotype of the genus was dredged.

Note on the operculum *Awarua amoena* (M. & S.).

I recently discovered in my cabinet a specimen of this species with the operculum in it. Unfortunately it is rather far down the aperture, and there are a number of sand grains adhering, but it is certainly of a conical type. Under a $\frac{2}{3}$ objective it appears to be spirally wound, with the outer edges free. At the apex is a small pit, from which the first coil arises, passing spirally downwards.

The Lake Ellesmere Spit

With Map, Sections and Photographs.

By R. SPEIGHT, M.A., F.G.S., F.Am.G.S.

[*Read before the Philosophical Institute of Canterbury, 2nd October, 1929; received by Editor, 5th February, 1930; issued separately, 29th May, 1930.*]

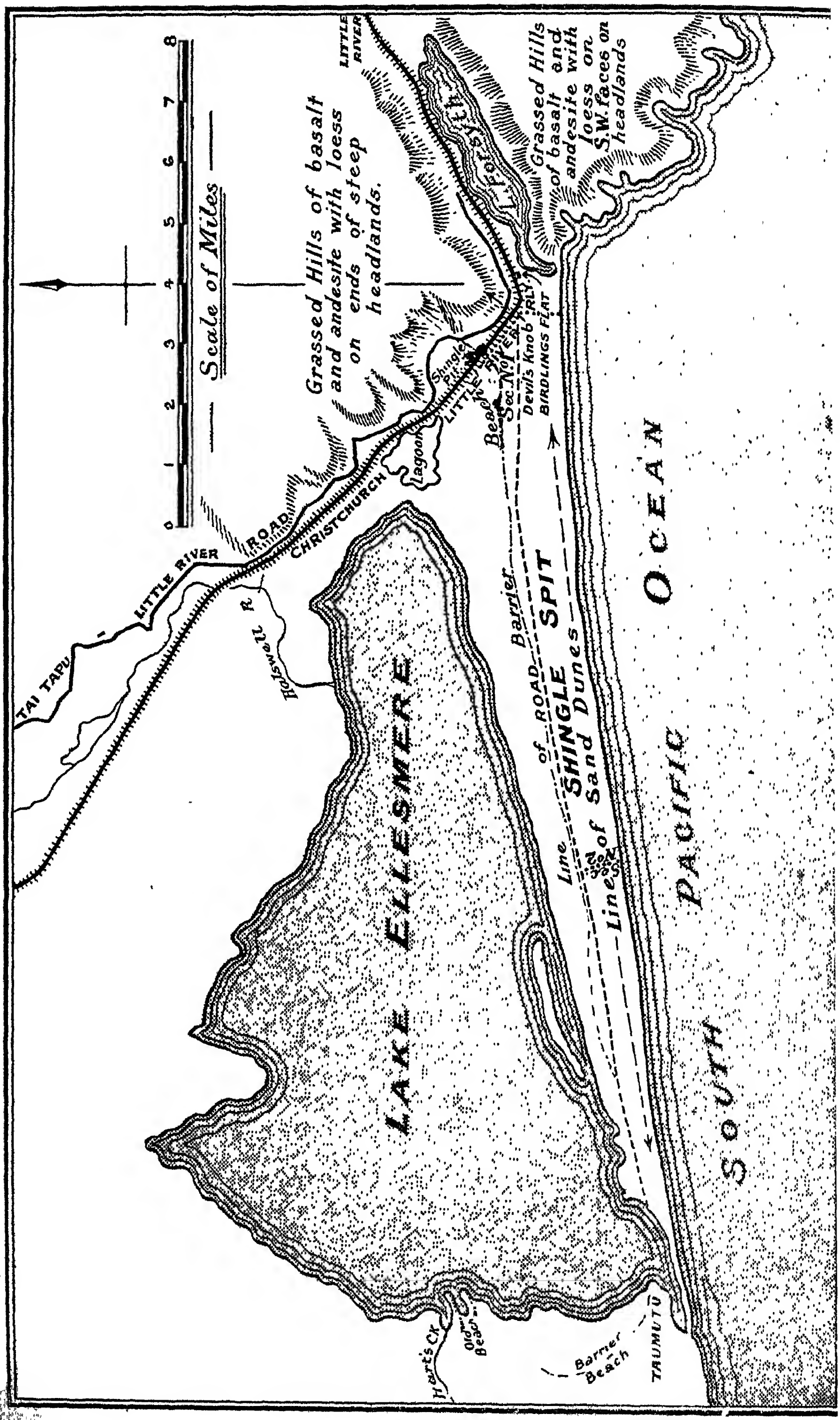
PLATES 27–33.

CONTENTS.

a. *Introduction* (see Map).

THE Lake Ellesmere Spit which divides the lake from the sea presents certain features of interest on account of their bearing on the recent geological history of the country in their vicinity. The spit itself, not taking into account the low-lying land on the southern margin of Lake Ellesmere subject more or less to inundation, stretches from the neighbourhood of Lake Forsyth and the old wave-cut cliffs between Birdling's Flat and the mouth of Price's Valley in a W.S.W. direction to Taumutu, the Maori village near the entrance to Lake Ellesmere. It is some 17 to 18 miles in length, about 2 miles wide at its eastern end near Birdling's Flat, a width which somewhat gradually decreases till at a distance of 10 miles it is about a mile wide, and it narrows to practically a few chains at Taumutu. Its area is approximately 12,000 acres. Its height above sea-level for the greater part of this extent is between 18 and 20 feet, but near a fringe of sandhills on the coast the level is higher, and there is a lowlying area on the lake side, hardly part of the spit proper, which is but a few feet above sea-level and lake-level; in fact when the lake is high portions in its vicinity are flooded. The spit proper is bordered on both sides by strips of land which are higher than the interior portion, and this presents certain features which an account should satisfactorily explain.

Near Taumutu the level of the spit falls and it becomes quite narrow (see Plate 30), so that seas break over it at high tide and render the water of the lake brackish. This is specially the case in

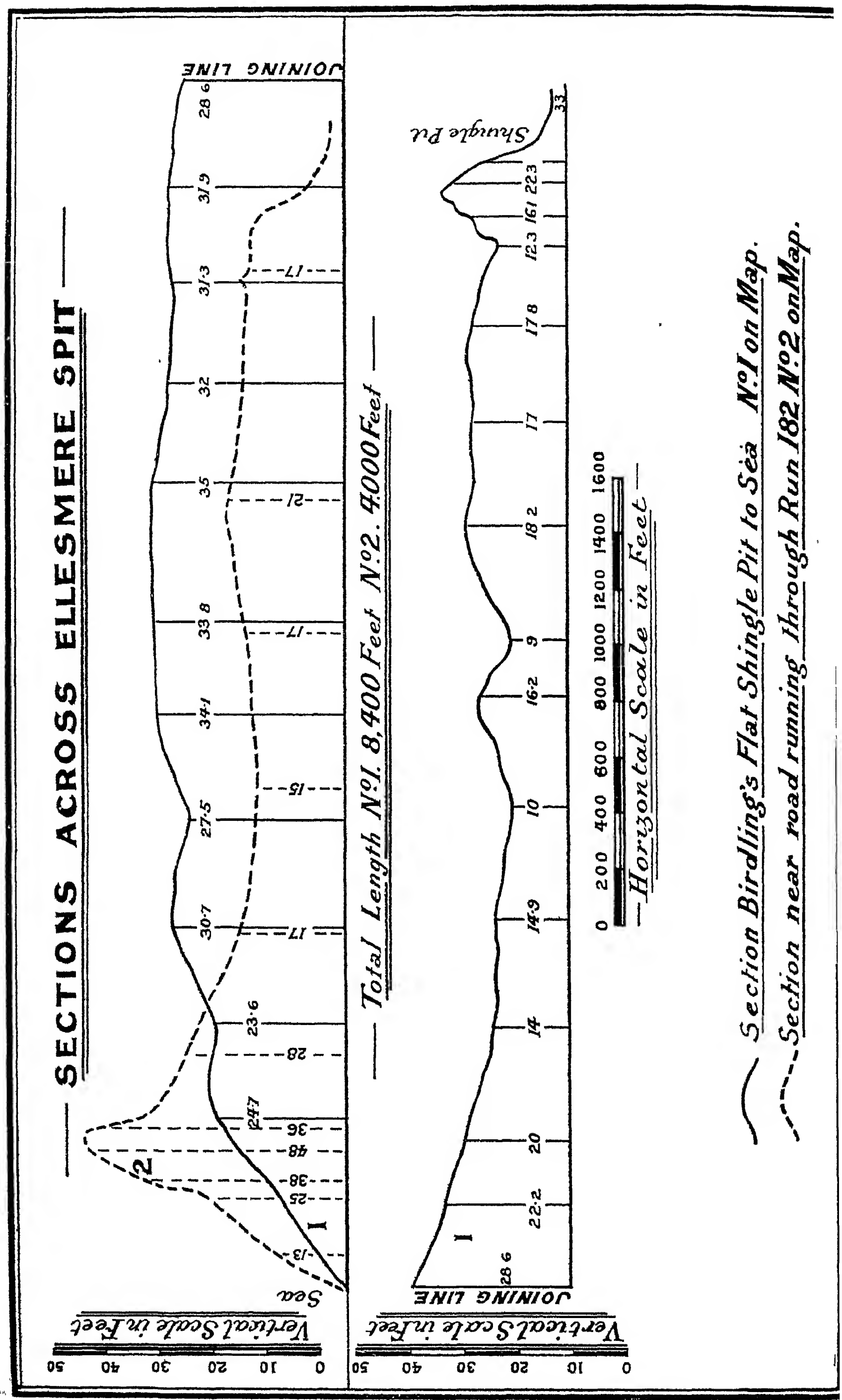

Scale of Miles
0 1 2 3 4 5 6 7 8
Grassed Hills of basalt and andesite with loess on ends of steep headlands.
LITTLE RIVER
L. Forsyth
Grassed Hills of basalt and andesite with loess on S.W. faces on headlands
TAI TAPU
LITTLE RIVER ROAD
CHRISTCHURCH
Halswell R
Lagoon
Shingle Pits
Devils Knob
BIRDLINGS FLAT
Barrier
Line of ROAD
SHINGLE SPIT
Line of Sand Dunes
LAKE ELLESMERE
OCEAN
PACIFIC
SOUTH
Hart's Ck
Old Beach
Barrier Beach
TAUMUTU

heavy south-east or south-west weather. When the level of the lake rises during the winter it has to be let out by a channel opened through the bank by horse teams and scoops. The rush of water rapidly cuts a path through the loose material, and the lake may remain open to the sea and tidal for a short time, but the first southerly storm blocks it up again, and if the bank is wide and the quantity of shingle thrown up great the level of the lake will rise once more and it will have to be opened again or the low-lying lands round the margin of the lake may be flooded. The water has been known to rise till the Lincoln–Little River railway has been submerged near Kaituna, a rise of approximately three feet. If the bank is narrow the percolation of the water through it, especially at low tide, is sufficient to prevent an undue raising of the water level.

Also there is a similar bank near the eastern end of the spit, ponding back the water of Lake Forsyth. This now forms a permanent barrier, except that in storms the water breaks over the bank and temporarily blocks a passage by the road which now follows along the barrier. However, in the early days of the settlement of the province, it was more commonly open and an old map records the existence of a Maori boat-harbour at the entrance to the lake, and represents it as being permanently open; it is known, too, to have been used by small trading schooners. This indicates that the outlet of this lake has only lately been permanently closed. When the barrier at the outlet is closed by especially heavy seas, which happens at a time when the level of the lake is raised by rains in winter, and by some addition from the sea itself, the low-lying lands at the head of the lake are flooded, and relief works are contemplated which will allow the surplus water to drain away at all times, whatever may be the state of the sea or the width of the barrier.

b. *Material of which the Spit is constructed.*

The material of the spit is almost entirely of greywacke, a fact which has considerable bearing on its origin, since it can only have come from the south. Banks Peninsula is almost entirely constructed of volcanic rocks—chiefly andesites and basalts—and the exposure of greywacke near the head of Lyttelton Harbour cannot possibly have furnished such material as is necessary to form the spit. There are occasional pieces of limestone and of volcanics, rhyolites and hypersthene andesites, especially the former, which must have come from the foothills of the Southern Alps between the Malvern Hills and the Rangitata River; the latter cannot have come from Banks Peninsula or from the north, so their occurrence only accentuates the evidence as to the southerly origin of the main material of the spit. One piece of well-rounded basalt, found about a third of a mile from the cliff near Lake Forsyth, resembles somewhat the basalts of Banks Peninsula, and may have come from there. Although several areas of basic rock are drained by the rivers to the south and this piece may have been carried down by them to the coast, the type of rock is somewhat different from any known to occur in connection with these areas.


SECTIONS ACROSS ELLESMERE SPIT
Total Length No.1. 8,400 Feet No.2. 4,000 Feet
Horizontal Scale in Feet
0 200 400 600 800 1000 1200 1400 1600
Section Birdling's Flat Shingle Pit to Sea No.1 on Map.
Section near road running through Run 182 No.2 on Map.
Vertical Scale in Feet
0 10 20 30 40 50
Joining Line
Sea
Shingle Pit
1
2

Included among the greywacke are numerous pebbles of siliceous rock, white, green, and red in colour. These may have come from the siliceous beds which in numerous places are interstratified with the greywacke, or they may have come from the amygdaloids occurring in the andesites near Rakaia Gorge, the Clent Hills, Gawler Downs, and other localities to the south where amygdaloidal andesites form important members of the exposed rocks. Both types, that is, amygdaloidal and jasperoid, are found among the pebbles. Two or three pieces of a hard white sandstone were also picked up resembling concretionary masses occasionally found in the Cretaceous Coal measures.

The possible sources of the material of the spit are two. First of all, there is the gravel brought down by such rivers as the Rangitata, Ashburton and the Rakaia, especially the last, and secondly, there is the material derived from the wear of the coastline. Haast (1879, pp. 399-400) has noticed the erosion of the fringe of the fan formed by the rivers which issued from the Mid-Canterbury glaciers in Pleistocene times, and the products of this erosion find their way north to the vicinity of the Ellesmere Spit. As the ultimate source of this material is the same as of that brought down by the rivers, the relative amount derived from the rivers and from coastal erosion cannot be determined. All the way from the mouth of the Rangitata to the vicinity of the Rakaia the sea-coast is bounded by a cliff formed of gravel. It reaches a maximum height of about 70 feet just north of the mouth of the Ashburton and diminishes in height both north and south from that locality, but the height remains fairly constant for miles in a northerly direction and only falls gradually to nearly sea-level near the mouth of the Rakaia. In the opinion of residents the coast-line is being eroded at present at a rate of between 2 and 3 feet a year. This must have gone on for a long time, since the gullies formed on the surface of the plains in the neighbourhood of Wakanui enter the sea discordantly, indicating that the marine erosion has proceeded so fast that the streams which occupy these gullies cannot lower their beds fast enough to make them accord with the sea-level. It is true that they carry less water than formerly, and probably date their initiation to a time when the climate was wetter, but the amount of the discordance on the sea coast indicates that a strip at least two miles in width must have been removed from the fringe of the fan. This furnishes at the present time a considerable supply of gravel, and in fact it may be primarily responsible for the formation of the spit. The total volume of spoil that the erosion of this fan would furnish is comparable with that contained now in the spit, taking due consideration of its area and the probable thickness of gravel it contains.

The pebbles forming the spit are invariably of the beach-shingle type, flat and well-smoothed. (See Plates 30-31). They range in size from pieces about 9 inches in diameter down to coarse sand grains, but the great majority of the pebbles are between an inch and four inches in diameter. The size of the pebbles appears to be greater along the present sea front and finer in the middle of the spit, and on the side facing the lake, but in places the external beach is made of sand and small pebbles. In the neighbourhood of Lake Forsyth

the quantity of sand appears to be very small, and the material is almost entirely of pebbles, as can be seen not only on the beach but also on the shore of the lake and in the gravel pits that have been opened in various places near the road and railway.

There is no doubt that during the strong winds that accompany southerly storms, large grains of sand and also small stones are easily transported from the coast. There is thus a fair admixture of this material in the surface layer of the spit, so that a poor soil is generally present on which grass and shrubby bushes become established.

c. *Form of the Surface.*

Although the general surface of the spit may be said to be flat, careful observations show that there are departures from this. In order to determine the cross section accurately, two lines of levels were run across the spit (see Fig. 2) by Mr. W. F. Robinson of the Canterbury College School of Engineering, and I am deeply indebted to him for this and for other help. The first of these lines crosses the spit from the point where the line of railway leaves the lake flats near the Railway Gravel Pit (Plate 27) to the vicinity of the Devil's Knob, the mass of rock terminating the spur immediately west of the Birdling's Flat railway station, and thence onward at right-angles to the coastline—there being thus a bend in the line. Another traverse was made across the spit about 10 miles from the railway.

The first part of Section No. 1 (starting from the shingle pit) shows the presence of a series of undulations, four in number, whose crests are approximately from 16 to 22 feet above sea-level, with hollows between them 7 feet lower. The convexity of these crests is directed towards the E.S.E. Near the road their direction is practically N.-S., but at the railway it has swung round for 15° and on the south side of the line its orientation is N.E.-S.W. and a little further on it is almost E.-W. The crests are reduced in number and become indefinite about 400 yards west of the railway, but a little further on the first continues again as a well-defined ridge for miles and will be referred to later.

The lowest point of this section across the spit is only 9 feet above sea-level and lies immediately west of the most easterly of the four ridges. After this ridge, height 16 feet, the ground is low, 10 to 14 feet above sea-level, and swampy in places for about 15 chains. This low-lying land extends for a long distance towards the W.S.W. down the heart of the spit, and is bounded by one or more ridges on the inner side facing the lake. From about the 16½ mile peg on the railway line the surface gradually rises towards the sea-coast so that where the road down the spit crosses the railway the level is 28.6 feet, and thence on for about 18 chains the level is maintained at about from 31 to 32 feet with minor undulations. Then it rises to 35 feet, a level which continues for about 10 chains, whence it falls to sea-level with two ridges and intervening hollows parallel to the coast. The ridges are at heights of 30 and 24 feet, and the hollows 27.5 and 23.6 feet respectively. The latter of these ridges continues as a well-defined crest right to the outlet of Lake Forsyth, and in its shelter the huts of the settlement there are constructed.

A noteworthy feature is the fact that the top of the spit is at this end of the section constructed of gravel and not of blown material, and since it is unlikely that any sea could build up a spit at a height of 30 to 35 feet above normal sea-level, it implies that the land was lower when the highest point of the spit was constructed, and that it has been raised since then. The two ridges mentioned above no doubt mark successive halts in uplift after the main part of the spit was formed.

The undulatory nature of the surface is quite characteristic, and in addition to the major waves shown on the section there is a succession of minor ones. These occur between the railway line at the Devil's Knob and the sea, and are more clearly seen from the top of the cliff, from which the lines of Wild Irishman (*Discaria toumatou*), marking successive undulations, are shown most distinctly, the bushes growing in the sheltered hollows between the crests. Between the railway and the sea, about 24 of these crests were thus counted, but it must be remembered that some are indefinite and merge into one another (see Plate 28).

Crossing the line of railway between the Birdling's Flat Station and the point of the hills lying about a mile to the north in the direction of Little River there are fourteen of these crests with a distance between them ranging from 20 yards up to 140 yards, the great majority of the distances being between 35 and 50 yards. It is impossible to give the distances exactly since the summit of the crest is usually indefinite and not determinable within a few yards. The convexity of the curve that these crests exhibit is directed towards the western shore of Lake Forsyth into what must have been an old bay between the site of the present railway station and the hills. From this station the crests get lower towards the hills, in fact the inner ones are from 6 to 10 feet lower than those near the station. The shingle of which they are composed is on the whole smaller in size than that nearer the beach, but there is an admixture of coarser material ranging up to 6 inches in diameter. There are layers of very fine as well as layers of coarser gravel exposed in the pits dug for road metal alongside the road.

A second line of levels was run by Mr. Robinson across the spit at a point about 10 miles from the Devil's Knob. This shows the coastal belt of dunes, and a fairly level surface for the main part of the spit with a marked drop to the level of the flats bordering on the lake. The height of the bank on the inner side of the spit appears to be accordant with that nearer the railway.

An important feature of the inner margin of the spit is a bank forming a line of rampart all along the inner face. This starts in the series of ridges near the railway gravel pit (Plate 27), but these soon peter out and leave a well-defined single ridge extending for about 12 miles down the spit. It is usually about a chain wide, with an outer slope generally of from 5° to 7°, but sometimes as low as 2°, and an inner slope of varying angle, but at times reaching as high as 20°. It rises at times as much as 13 feet above the ground at the back of the spit, but its height is usually from 3 to 6 feet (see Plate 29). Between Mr. Bailey's house, about 11 miles down the spit just beyond Section No. 2, and the late Mr. Willey's house about a mile

further on, its height is in places as much as 18 feet. Occasionally, however, its surface merges into the general level of the spit (see Section No. 2). On the side facing the lake the fall is usually steep for about 6 feet, and then it flattens out and merges into the level and swampy ground facing the lake. In some cases there is a well-defined beach about 7 feet below the level of the crest, and very occasionally the slope is gradual towards the lake. At times, too, the beach merges into the general level of the top of the spit and then a new barrier continues as a switch line in front.

The ridge itself has thus all the characters of a barrier beach, and if that is its origin it must have been formed when the surface of the spit was practically awash in stormy weather, that is, the land must have been some 12 to 15 feet lower than at present. This lower level corresponds with the lower level demanded by the shore platforms cut at the base of the cliffs to be mentioned later.

In some places in front of the ridge there are hollows of considerable size, sometimes over a chain across, like sink holes in appearance whose mode of formation is difficult to explain. The largest of these is five chains long and two chains wide and contains water on the floor. Most of them are dry at present and do not appear to contain water at any period of the year. Spring holes of considerable depth do occur along the flats near the lake and the holes referred to may be due to a similar cause. Some of them are practically at lake- or sea-level, although separated from both by a considerable width of land.

On the inside, i.e., the south side, of the bank the low ground at times extends for long distances, and the depression includes a considerable area of ground. This is notably the case near Mr. Bailey's house, where there are numerous old Maori ovens of large size, indicating prolonged or repeated occupation, the plentiful supplies of fish and birds from the lake, also the quantity of drift wood from the beach, as well as the shelter from the wind afforded by the bank rendering it a favourite camping place. Maori ovens are also found in other parts of the sheltered ground, especially when the bank is somewhat higher than usual.

About 10 miles from the eastern end of the spit the form of the surface becomes more complicated. The bank is broader, up to about a couple of chains, but still well-defined, bare of vegetation as if it had recently been raised. In front are a number of subsidiary ridges marking former levels of the lake in its retreat from the main ridge. These extend for some distance to the west, parallel to the bank. On the inside the well-marked depression behind the bank, referred to previously, tends to disappear and its place is taken by many clearly marked ridges, analogous to those seen near the Birdling's Flat Station, but with a much shorter distance from crest to crest.

At this point the general trend of the barrier beach is about E.-W. but the trend of the crests inside this is first of all N.E.-S.W., but on going towards the west their direction becomes E.N.E.-W.S.W., and further west still they become E.-W., that is parallel to the general trend of the barrier beach in that section. The convexity is thus directed towards the E.S.E. There is a succession of crests, at least

seven in number. They almost block the end of the hollow mentioned as extending from near Section No. 2, past Mr. Bailey's and Mr. Willey's houses, and when followed west they merge into the general surface of the spit.

On the inside of this section, not only where the complex of crests occurs, but also where the inner margin of the spit is more defined, there are projections of gravel extending from the line of the barrier beach, with hollows in between, so that they take the shape of an embayed margin. These are apparently formed by seas breaking across the barrier and carrying material into the lagoon on the inner side, building out blunt tongues into the shallow water, just as may be seen forming now where the sea breaks over the barrier beach into the lagoon north of the Rakaia mouth. These naturally date from the time when the land was lower and the surface of the barrier beach practically awash during the heavy seas that occurred in the open space where the lake now is. The convexity of the crests indicates that the seas before this came from a slightly different direction than when the barrier was formed.

Coastal dunes continue from about two miles south-west of Lake Forsyth right to Taumutu. The belt extends to several chains in width, but narrows towards the western end of the spit. It is well defined and the summits of the dunes present a somewhat accordant summit level, being about 50 feet above sea-level or from 20 to 25 feet above the general level of the spit. The front facing the sea is usually steep, but the inland side merges into the prevailing level of the spit with more stabilised dunes, not so high, lying inside the higher summits. In some cases there is a double row with level ground between. About 8 miles down the spit the dunes appear to be attacked by the sea, while further north the shore appears to be prograding. It has a different form, and drift timber appears half buried in sand a chain or more from the storm-water mark.

Mention should also be made of the old beach which lies across the mouth of Birdling's Valley immediately to the west of the point where the spit ties on to the solid land. Its level is accordant with the top of the spit in its vicinity, and it was evidently constructed when the barrier beach was formed, at a time when the land was lower. It was no doubt due to seas from the west breaking directly into the mouth of the valley, then no doubt a bay facing to the west.

Another interesting occurrence is to be seen at the base of the hills in the embayment north of the road west of the Devil's Knob. Here the following section rests on a base of volcanic rocks:

1. *Loess*, passing up into burnt soil, with charcoal fragments, containing angular pieces of burnt rock (basalt), with shell fragments in the upper dark coloured part. Some of these shells are marine and others fresh-water, the latter being of *Diplodon menziesii*.
2. *Beach gravel*, 15 to 18 inches thick, and extending right across the embayment. This is at an estimated height of 12 to 15 feet above the level of the railway across the road. Its height does not equal that of the summit of the spit at its highest point.

There appears to be no reason against the conclusion that the beach gravel lies in position on the top of the burnt material, which is apparently of Maori origin. If this is so, important changes in level have taken place since the occupation of this part of the country by the Maoris. It would mean that the land had sunk so as to allow the old ashes to be covered by marine material, and then raised till it was above the reach of the waves.

d. *Nature of the Beach.*

In the vicinity of Taumutu the principal constituent of the sea-beach is shingle of the true shingle form (Plates 30-31), the size ranging up to about 10 inches in the longer diameter. There is also an admixture of smaller material ranging down to fine sand. As a general rule the part of the beach which is composed chiefly of pebbles of an average size, i.e. between 2 and 3 inches, is that lying between ordinary tide marks. Towards the lower limit of the tidal belt the material becomes finer, while in the direction of the upper limit of the tides the sand increases in amount till it passes into pure dune. In this portion the average size of the occasional pebbles is larger than on any part of the beach (see Plate 30). I take it that these stones have been thrown up by big storm waves and have not experienced the continual attrition which affects pebbles on the belt between tides. It is thus clear that the finer materials of abrasion are removed from the ordinary tidal belt, some are swept downwards and distributed on the sea-bottom by the backwash of the waves, etc., and some are carried away by the winds, the large pebbles referred to above being exceptional.

Further north-east, sand forms the dominant material of the beach, and I have no knowledge of its precise origin. This continues till Lake Forsyth is approached (Plate 31), when the finer constituent becomes relatively unimportant. It may be that by the time this locality is reached in the drift up the coast, all the finer material has either been blown away to form dunes, or been reduced to mud and swept out to sea, the latter in accordance with the views expressed by Marshall as to the effect of attrition on beach pebbles. However, it must be pointed out that the beach between the mouth of the Rakaia and a mile or two south of Taumutu is dominantly of gravel with little fine material, and this is especially true for a few miles north-east of the Rakaia mouth.

Observations of the angle of the beach made in different localities show that it is remarkably uniform, and that the inclination from the foot of the sand-hills down to low-water mark is from 4° to 5°. This is also the case further south-west between the Rakaia and the mouth of the Ashburton.

e. *Structure of the Spit.*

The structure of the spit is difficult if not impossible to determine as there are no cuttings, natural or artificial, except the beach and the gravel pits near the railway. The first of these gives no indication of structure, but some idea can be obtained from the latter.

The most interesting of the pits is that where the railway meets the spit about a mile on the Christchurch side of the Birdling's Flat Railway Station. At the further end of this excavation the lowest beds are exposed, composed of fine-grained material, well stratified, with layers lying flat or dipping south-east at angles with a maximum of 25°. Over these beds lies well stratified gravel with a uniform dip of 10° to the north-west, which continues uniform for a distance of 15 chains as exposed along the northern face of the pit (see Plate 32). The layers are generally of fine material, the larger pebbles of the fine layers up to an inch in diameter with a general average of half an inch, and with a considerable admixture of coarse sand and finer material. Inter-stratified with this are layers of somewhat coarser material in well defined layers, composed of pebbles generally up to 2 inches in diameter, and with occasional larger stones up to three inches. The stratification of this is definite and clear, and indicates that deposition took place in fairly quiet water, and not on an exposed beach. An angle of dip of the bedding as high as 10°, which may be taken to be the angle of slope of the beach as it was constructed, would indicate according to Marshall (*loc. cit.*) that it had been laid down in sheltered water—the angle of slope according to this authority being flatter where the seas are heavier, the size of the material of which the beach is constructed being constant.

The break in stratification shown in the section in the shingle pit is definite and clear, and indicates an abrupt change in the conditions at one stage in the formation of the spit. Such a change, not necessarily at the same time, is also indicated in the arrangement of the ridges noted above about 10 miles down the spit.

In the extensive gravel pit at the turn of the railway near the Devil's Knob the stratification is also well developed, the beds dipping seaward at low angles. One method of forming stratified deposits in connection with a spit is shown at the seaward end of Lake Forsyth and near the outlet of Lake Ellesmere. In both these places heavy seas have carried the shingle over the barrier into the lake and sorted it into layers. The regularity of the stratification in the case of the former suggests that the deposition took place in the lake itself, but it is quite possible that the sorting action is due to the rush of the water over the barrier as seems most probable in the case of the outlet of Lake Ellesmere. The stratification in the first-mentioned gravel pit is no doubt due to the beach being formed in the somewhat sheltered waters of the lake by waves coming in from the west. The direction of the convexity of the crests in its vicinity supports this contention. A similar stratification to that occurring in these pits and due to a similar cause is known in the barrier beach between Taumutu and Hart's Creek, to be referred to later.

Little can be said concerning the basement beds of the spit, since there are no natural exposures and no bores with proper logs have been put through the shingle—the only wells being shallow ones and the water from them strongly saline. At low tides a bed of clay is exposed near the outlet of Lake Forsyth, and clay beds are also exposed near the other end of the spit at Taumutu, and blocks of sandy clay, up to 12 inches cube, are found on the beach just south

of the outlet of the lake, which indicates a similar bed to occur in the sea in close proximity. With the evidence at one's disposal it cannot be said whether or not these beds are mere discontinuous lenses or parts of an extensive sheet of clay, continuous with the clay beds beneath Lake Ellesmere.

f. *Wave-cut Cliffs.* (See Plate 28).

The eastern end of the spit is marked by a definite wave-cut cliff. Near the Devil's Knob it is some 280 feet high, with a height of 400 feet to the east of Lake Forsyth. There is also a pronounced bluff varying in height from 200 to 300 feet to the west of the road from Birdling's Flat Station towards Little River which must have been cut by the sea. On the face of these cliffs are exposed the ends of the layers of volcanic material—lava-flows and beds of agglomerate —of which the Banks Peninsula hills are formed. There is no doubt that these have been wave-cut, and at a time when there was no spit or when the land was submerged so as to allow the waves to break against the ends of the spurs. The upper surface of the ends of the spurs is covered in many places with loess.

Indications of this wave-cut cliff occur to the west, all along the road towards Tai Tapu, but it gradually loses its definiteness when traced to the west, so that the spurs near Tai Tapu and further west still have no cliffed ends, but gradually sink down to plain-level as the spurs of the islands inside coral reefs sink down to the sea. This indicates either that a subsidence of the land took place sufficient to mask the ends of the spurs with alluvial deposits, or that they were not exposed to strong wave action, the latter alternative being the more probable.

When they were formed the height of the shore platforms along the road clearly shows that the land must have been at least 10 feet —perhaps 15 feet—lower than it is now. Of course it is not clear from the form alone whether the cutting was done by waves in a lake or in the sea, but as I will show later there is clear indication that the land was lower at one stage in the history of the spit, that its surface was practically awash, and the cutting might have been done when the sea had access to the area now covered by the lake. If the cutting had been done by lake waves only, then the lake must have been from 12 to 15 feet higher than now relative to the Peninsula, and in view of the low height of the bank of the spit near Taumutu this appears to be very improbable.

On the exposed southern coast of Banks Peninsula in the direction of the entrance to Akaroa Harbour there is little sign of these platforms. In some cases reefs run out which are exposed at low tide, and which may be the remnants of the platform that have escaped destruction by the heavy seas, but in any case it would be surprising if any definite remnants should be visible on this exposed coastline. Any platform occurring may have been determined by hard layers of basalt rather than by the sea operating at a higher level than at present.

g. *Origin of the Spit.*

From the shape of the pebbles of which the spit is composed, as shown in every exposure, it is clear that it has been formed by wave action and that the material has come from the south; it is also clear that the active transporting agent has been the waves acting on the shore during heavy south-easterly and south-westerly gales. Either of these is sufficient in strength to account for the transport of material along the beach.

The wave action has no doubt been helped at times by the current that flows from the south up the east coast of the island. It is difficult to obtain evidence of the strength and direction of this current. The Admiralty Chart of the coast from Akaroa to Dunedin, revised in 1922, gives no indication of its strength except that in the vicinity of Otago Peninsula it is a 1-knot current, and also that after south-easterly weather there is a set into the Canterbury Bight. As the chart gave no satisfactory evidence I wrote to a competent marine official at Timaru and he gave in a letter very interesting information as to the currents. He said that shipmasters stated that very frequently the set in the Canterbury Bight was to the east and not always as stated on the chart into the bight. Also that very frequently when the Rangitata and Opihi were in flood the water found its way south to Timaru, that barrels washed off ships' decks north of Timaru had been picked up south of that port, and also that only occasionally ships experience a current against them when travelling from Akaroa to Timaru. However, most of the material shed from ships and wharves near Timaru found its way up the Ninety Mile Beach. He was also of the opinion that an eddy occurred in the Canterbury Bight which accounted for the strength and variability of the currents off the coast.

I also wrote to the late Captain Bollons, of the G.S.S. Tutanekai, with regard to this matter and he answered as follows in reference to the longshore currents of the Peninsula and coast south of it: "These are simply surface streams formed by the prevailing weather. In the days of sailing craft several vessels were lost along shore between Ellesmere and Timaru set in by the currents created by south and south-east gales. As the prevailing winds are south-west and south-south-west, the drift is also from that direction. In small sailing vessels we could always beat a passage north but this could not be done bound to the southward. With hard north-east, north, and north-west winds a set occurs round the Peninsula and alongshore past Ouraki and Peraki and into the bight. There is certainly an eddy or an area of no current between Akaroa and Ellesmere during moderate weather conditions, but with any strong winds the surface set runs with the weather. We experience this when at anchor off Akaroa Heads."

In discussing this matter Mr. Coates, a fisherman at the mouth of Lake Forsyth with many years' experience, said that the drift near the shore was invariably from the south, and that most of the drift wood found near the outlet of the lake was gorse, broom, and lupin sticks such as grow freely in the river-beds to the south. He said also that about three miles out there was a strong current run-

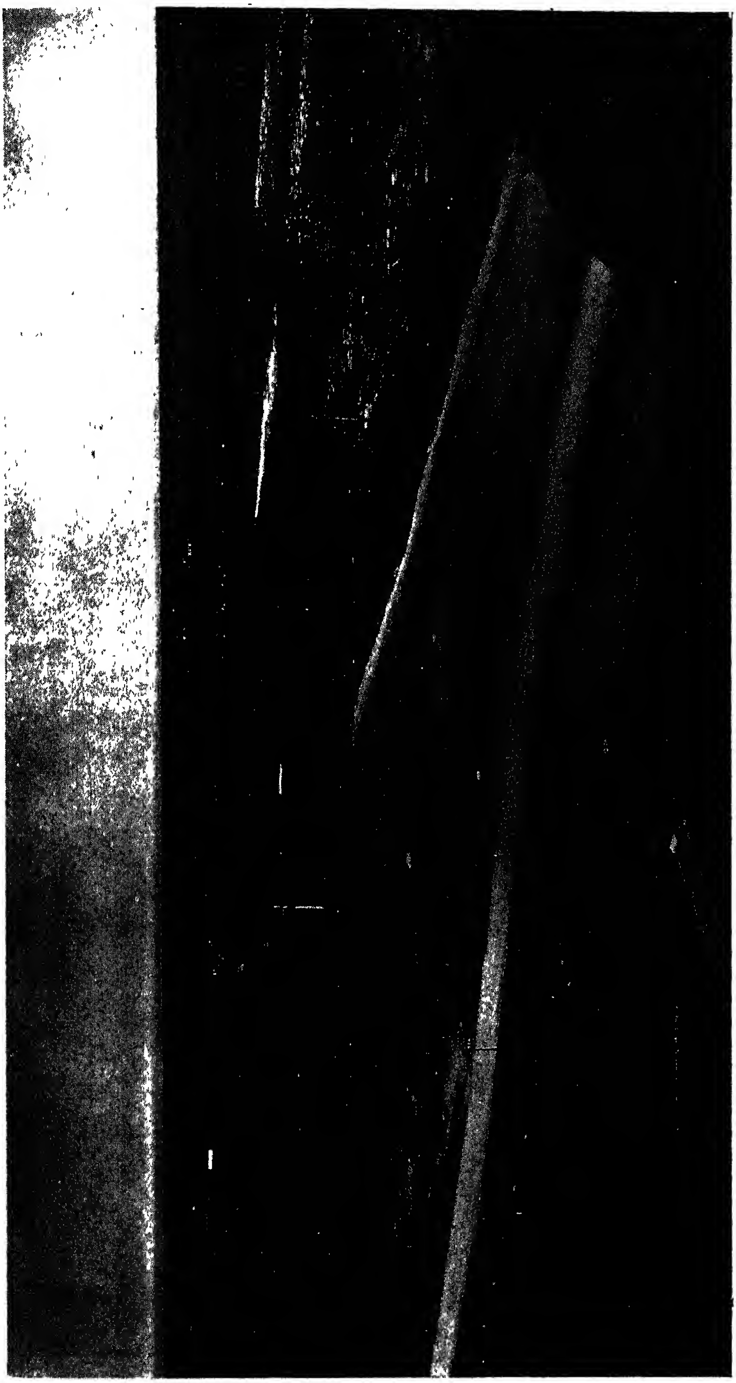
ning towards the south from the direction of Banks Peninsula even in quiet weather, but this was intensified during north-east gales till the current approached 4 knots. Between the two was an eddy where flotsam accumulated.

Thus the main influence which affects the coastal drift of shingle is the waves aiding currents induced by the winds. This coastal drift is prevailingly from the south although there may be an eddy during certain weathers on the south side of the Peninsula which causes a set to the south-west. This is, however, some distance from the shore and does not affect the question. The force of the waves during storms is very great, for example during the great storm in January, 1929, when the Timaru breakwater was damaged, the waves came right up to the top of the bank near the huts on the south side of the entrance to Lake Forsyth, approximately 25 feet above normal sea-level. This is exceptional, and storms of moderate intensity must be looked on as the determining factor in transporting material along the belt where the waves act.

The northerly movement is aided by the fact that the sea deepens very gradually off shore. The charts show a depth of from 10 to 12 fathoms at a distance of from 4 to 5 miles off the coast near the mouth of the Rakaia, 10 fathoms five miles off Taumutu, with a gradual approach of the 10 fathom line to the coast in the direction of the Peninsula. This indicates that the grade of the sea bed off the Rakaia and Taumutu is not appreciably different from the grade of the plains near those places. This means that during storms the waves affect a somewhat broad belt parallel to the coastline.

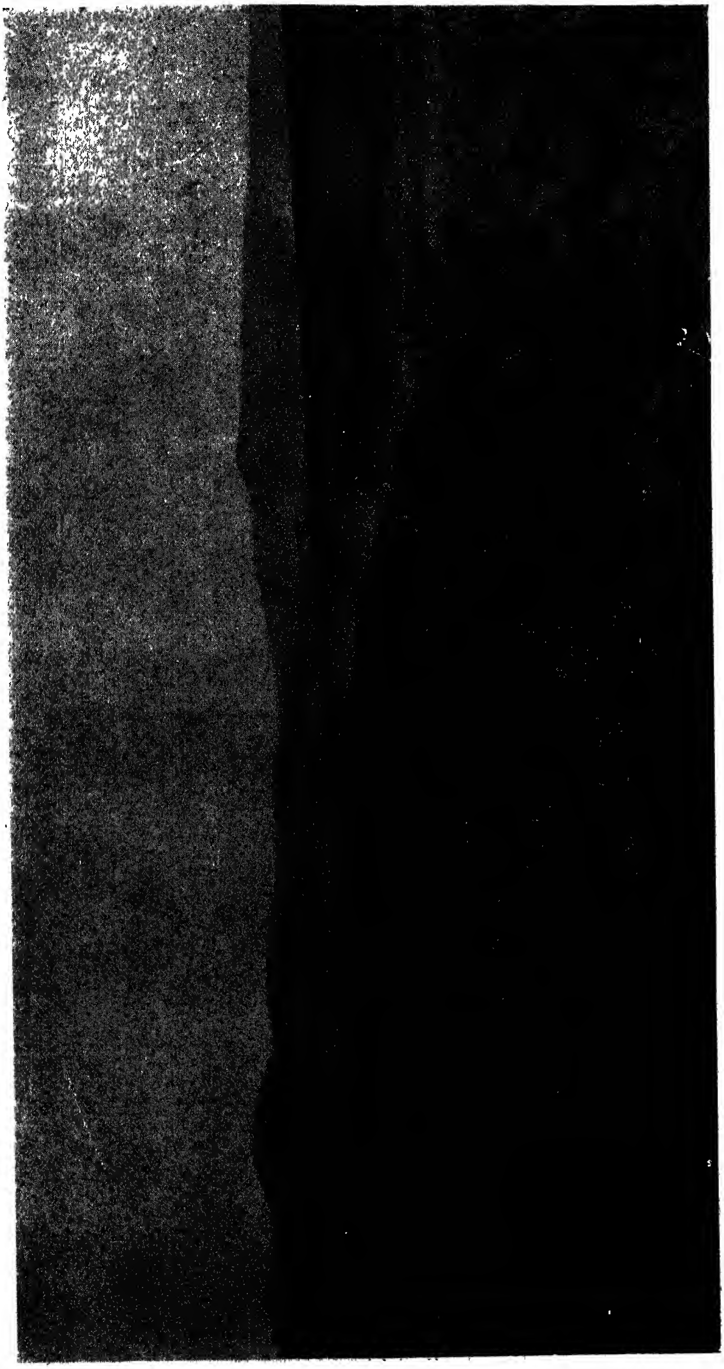
Although it is manifest that recent aggrading of the coastline is now going on in the vicinity of the outlet of Lake Forsyth, it must not be assumed that it is going on over the whole length of the spit at present. The reach where the sandhills are developed in certain places gives evidence of strong sea attack, in fact it seems possible that were natural agencies left to work out their ends, a break through of the sea might take place some miles to the north of Taumutu.

A somewhat surprising feature of the spit is the absence of a tidal opening alongside the cliff at the present eastern end. If the spit has been formed by drift up the coast then we should expect it to be built up from the west, and following the usual sequence of events the opening should exist as long as possible at the western end, and specially so when at that end there is solid rock along which an open channel can be kept. In the case of Lake Forsyth we can see how such a channel has been kept open along the eastern side of the lake until just recently under circumstances apparently not so favourable as those which might be expected to have obtained at the present root-end of the Ellesmere Spit. Why the entrance should have been closed in the case of the larger lake and kept open in the case of the smaller one, the drift affecting each equally, is not clear, since the drainage area of the former is much larger and contributes much more water than does the latter, and when the Waimakariri, and perhaps the Rakaia also, discharged into the lake the amount of water coming in should have been greater still, and have helped to



General view of the Spit looking westward from cliffs half-mile west of Devil's Knob, height 200 feet. The line of the barrier beach can be seen running diagonally across the picture. Railway gravel pit in left middle distance.

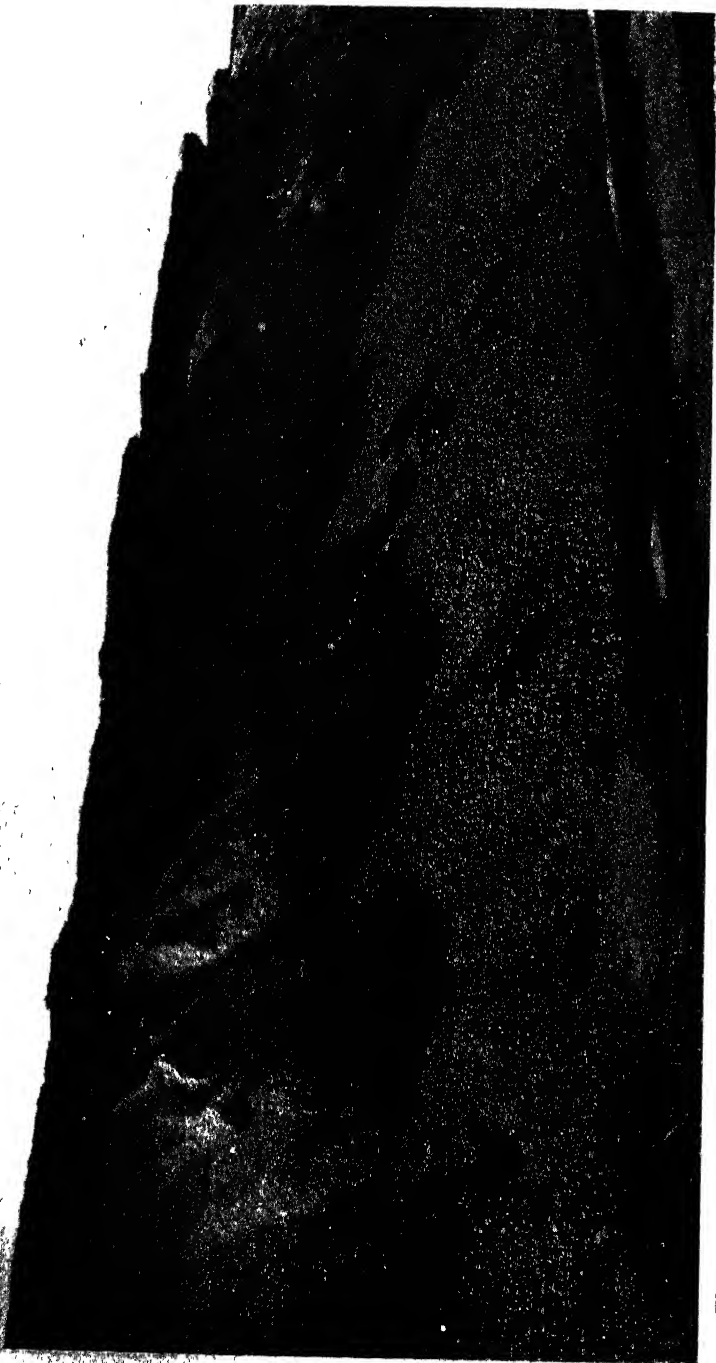
View looking east along the southern shore of Banks Peninsula, showing cliffed spurs, capped with loess, the blocked outlet of Lake Forsyth in the middle distance, and the spit with the crests of the ridges and the hollows in between indicated by the lines of scrub.



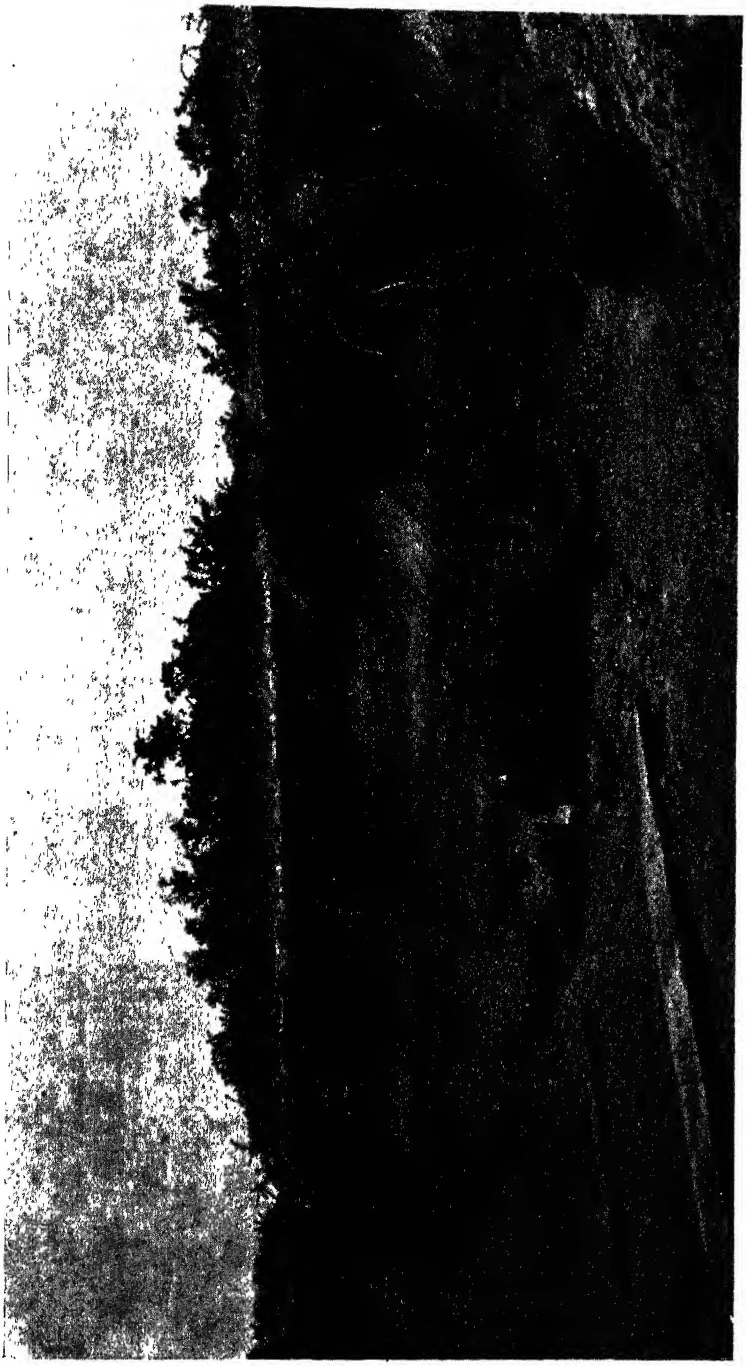
The raised barrier beach looking east; view taken from a point about 6 miles from the eastern end of the spit.

The beach near the outlet of Lake Ellesmere, looking north-east. The largest stones appear among the sand near the crest of the ridge dividing the lake from the sea.

Beach near outlet of Lake Forsyth, looking west. The pure shingle of this part of the beach, and the form of the pebbles, is clearly shown.



The railway shingle pit on the inside of the spit between Birdling's Flat Station and Kaituna. The stratification is well marked, as well as the break, seen towards the right of the picture. The angle of dip to the left is 10°.



Stratified gravel on barrier beach between Taumutu and Hart's Creek, to the west of the lake. These beds dip uniformly lakewards at an angle of 5°.

initiate and maintain a permanent opening at the Birdling's Flat end.

The position of such openings has been dealt with by Marshall in his Geology of New Zealand (pp. 76-8) and special reference made to the Ellesmere Spit, but I am not quite certain that his explanation is satisfactory as applied to this case, although it is quite reasonable in others.

It is possible that the opening has only recently been closed, although the earliest maps of Canterbury indicate that it was closed for half the year, in the forties of last century, and that this closing may be due to a recent increase in the amount of shingle derived from coastal erosion to the south, but it is remarkable if all the shingle forming the spit has been transmitted along such a slender line as exists now. It suggests that the history of the spit is even more complex than appears to be the case, and that it may only be a remnant of a larger spit which was constructed further seaward when the land was higher, and which is now submerged beneath the belt of shallow water which fringes the spit on the seaward side. This is only a speculation and at present there is no solid evidence on which it may be based, but the peculiar circumstances of the Taumutu end of the spit are not easily accounted for and some such explanation appears to be necessary.

Along the seaward face of the sandhills there are numerous stumps of totara (*Podocarpus totara*), many of them standing on their roots with the lower part of the trunk vertical, and up to six feet in height. They occur just above high tide mark, and their roots are washed and frayed by drifting sand and gravel, so that all the fine rootlets have disappeared. The top foot or so of the higher trunks is riddled with teredo borings, while the remaining portion is free from them or only shows an occasional hole. This is a point difficult to explain on the assumption that they are entirely drift material, unless for some reason or other the roots and lower part of the stem of totara are not susceptible to the ravages of the ship-worm.

Presuming that the material is drift, and it seems certain that some of it is really so, it can only have come from two districts, (1) Banks Peninsula and (2) the Rakaia Valley. The hillsides of the former were formerly noteworthy for the fine totara trees that grew on them, and they may have been swept down from the Little River Valley or from the Peraki Valley further east, but as the stumps occur beyond Taumutu, this implies a definite current sweeping round the southern side of the Peninsula from the east and continuing southward along the face of the spit, in a direction contrary to the prevailing set of the sea. This may be possible, according to the evidence given in Captain Bollon's letter (p. 159 ante), but if so there should be some admixture of Banks Peninsula volcanics in the material of the spit, and I have found none for certain. In the upper valley of the Rakaia there is a quantity of totara growing, but if the drifted material has come from there, a greater quantity of beech timber should have been associated with it as the beech areas in the valley of that river exceed those where totara grows in extent. However, only an occasional piece of this timber is to be seen, and then

only as fairly small fragments never with roots attached. The stumps, too, are larger than any I have seen in the forest of the Rakaia Valley. So that the drift material has in all probability come from Banks Peninsula.

I have considered carefully the question as to whether or not some of this material may have been due to the remains of a forest that actually grew on the spit. It is admitted that there were no trees there within the memory of the earliest inhabitant, but it is not altogether an unlikely place for a totara forest to occur. As pointed out by Cockayne in his *Vegetation of New Zealand* (2nd Edition, p. 95) totara is a characteristic feature of the plant covering of dunes, and further I am informed by Mr. F. E. Hutchinson, of the School of Forestry, Canterbury College, that a narrow belt of totara about a chain wide is growing on the sandhills between Hokitika and Ross on the West Coast of this island, in a position exactly analogous to that on the Ellesmere Spit. If so, it demands, first of all, that the spit must have been higher for the trees to be established at all, and then must have been lower than at present to have the tops of the stumps bored by teredo. It is of course possible that these bored stumps which at times stand well back from the beach, are drift wood of a previous epoch, that they were submerged and bored when the land stood at a lower level, and the fact that only the upper portions are bored may be explained by supposing that the lower parts were protected from the teredo by sand and shingle accumulations round the base of the stump. It can hardly be due to the limitation in the range in depth at which the animal works, for the change from bored to unbored wood would not be so abrupt, and it is known that the borer works at depths much beyond what is demanded by the evidence for submergence of the land in this case. As totara is such a durable timber there appears to be no impossibility that these stumps may have been a remnant of old drift wood or of trees growing in position before the submergence of the land. If this explanation holds, then it demands that the land must have been at least 12 feet lower than at present, a conclusion arrived at on entirely different evidence.

No other timber has been discovered on other portions of the spit, and this is decidedly against the contention that a forest may have once occupied it. There should have been some remnant. All the same, the totara which may have formed a fringe of such a forest would survive as logs and stumps long after all the other material had decayed. However, on the opposite side of the lake there is a wide and continuous belt of country where there are the remains of an old forest, mostly kahikatea or white pine (*Podocarpus dacrydioides*) which was exterminated on the low-lying land before the arrival of the white settlers. And as we know that the land has recently been lower and the surface of the spit awash, entirely apart from the evidence of the teredo borings, it is possible that this white pine forest was destroyed at the same time. Some of the taller stumps of totara occur now at the south-western end of the spit, and if the land were slightly higher then this white pine forest must have extended as far as this and may have joined with a supposed belt of totara growing along the coast.

The correctness of this hypothesis is supported by a statement given to me personally by Mr. A. Dudley Dobson, M.N.Z.S.E., that when investigating a site for a culvert through the spit to drain the lake, he came across stumps of trees in position resting on a bed of clay exposed on the beach and visible at low tide level. The possible extension of the forest is also supported by the presence of submerged standing stumps in the lake about a mile north-east of the mouth of Hart's Creek.

If the circumstances attending the formation of the spit were such as have been outlined then there should be traces of a similar spit on the western side of the lake, formed at a time when the land was at a lower level than at present, and when the sea had access at the Taumutu end. This does certainly exist. Extending from the vicinity of Taumutu along the lake margin in a northerly direction for about two miles is a well defined barrier ridge, composed of beach shingle, well stratified where exposed, and exactly analogous to that on the southern shore of the lake. Its height where it has its greatest elevation is about 17 or 18 feet above the level of the lake, and it is remarkably level on top. The width of the summit is about a chain and it falls gently inland, but presents a fairly steep slope towards the lake. Where the stratification can be observed it is very well defined into layers of coarser and finer material, the largest stones being about three inches in diameter (see Plate 33). On the flank facing the lake the angle is about 6° but on the top there are indications that it flattens out. There is no exposure on the westward face to enable the structure to be determined.

In front of this beach there are at least two others before the level of the lake flats is reached, these are at about 7 feet and at 4 feet above lake-level, and the former of these, especially in more or less sheltered positions, exhibits a well marked barrier form. The topmost beach grades into the complex of beach material on which the township of Taumutu is placed. This must have formed a well marked blunted point or buttress when the land was at a lower level and the sea entered the lake. When traced in the reverse direction towards Hart's Creek, the barrier beach rapidly sinks about two miles from Taumutu, but a lower ridge is continued for another three miles, sometimes very indefinitely developed and then again quite clearly seen. Stretching at right-angles from this ridge out towards the lake are three definite spits, as well as another complex of beach deposits, at a lower level than the main ridge near Taumutu. The most prominent of these is just south of the outfall of Hart's Creek, in the lee of which is a considerable area of sheltered water. They are only a few feet above the lake and at times of high water the lower parts are awash. Behind the main ridge and its extension lies a stretch of exceedingly good land formed from the swamps which once fringed its inner margin, but which have now been effectively drained.

There is thus on the western side of the lake such a ridge as might have been anticipated from the conditions governing the formation of the major spit. Its existence emphasizes the fact that the sea had access to the lake while the barrier beach was being formed, for the ridge just described could only have been formed by the sea.

If it had been formed by the lake it should have been more or less continuous round its western and northern shores, whereas the break at Hart's Creek is what might have been expected had it been formed by the sea as it entered the area now occupied by the lake, and the nature of the pebbles forming the ridge supports this contention since they are almost entirely greywacke. Had the ridge been formed by lake waves alone there should have been a considerable admixture of Banks Peninsula material since the dominant wind on the lake is from the north-east, and this would have ensured that a drift of volcanic material should have come from that direction.

h. *Changes in Level of the Land.*

The following is a table showing the probable changes in level in the locality:

1. Higher land when valleys on the peninsula were eroded.
2. Depression, accompanied by invasion of valley floors by the sea.
3. Practical still-stand, no major movement when spit was constructed.
4. Depression till the spit was awash and barrier beach constructed on the lake margin, and the boring of the stumps now exposed on the seaward margin. At this time shore platforms were cut on the ends of the spurs along the Tai Tapu–Little River Road.
5. Elevation of from 12 to 15 feet, the present level.

It will now be advisable to compare this sequence of events with any chronology of movements of the land indicated in the adjacent districts. To the south there is definite evidence of a downward movement of the land in the neighbourhood of Timaru, the drowned river stream valleys incised in the edge of the Timaru Downs, as well as the presence of submerged forests at Pareora and to the north of Timaru indicating such a movement clearly. Further north the dominant feature of the sea coast, that is, the sea cliff north and south of the mouth of the Ashburton River, and specially between it and the Rakaia, postulates long continued erosion, with little change in level of the land. There may be a slight downward movement, but an upward movement is not ruled out, since the attack on a somewhat easily eroded shore line might rapidly obliterate any shore platform or marine terrace that might have been formed. Between Taumutu and the Rakaia mouth there are lagoons ponded back behind a barrier beach, but these can be explained without any demand for a sinking sea-coast, although some slight movement in that direction may have occurred. These lagoons and other pieces of swampy land may quite well represent shallow salt-water areas that have formed behind a barrier beach, and have been partly filled with detrital matter so that they are slightly above sea-level and are now fresh, if containing water, or have been turned into swampy land.

On the northern side of Banks Peninsula there is evidence of recent uplift of from 12 to 15 feet as suggested by Haast, Speight and Jobberns. This will naturally correlate with the uplift inferred in

connection with the spit. There is also evidence for a higher level of the land from the records of the artesian wells of Christchurch in that peat beds occur at various horizons down to 600 feet beneath the present sea-level. The peat must have been formed on a land surface, so its present level demands depression of the land since it was formed. Inter-stratified with the peat and gravel beds are others containing the mollusc *Chione stutchburyi*, a marine and estuarine form now living chiefly between tides. These shells are also found in the bores put down in places like Lower Riccarton, Ladbrooks and Greenpark, and no doubt they occur also at Halswell and Tai Tapu between these three places, but the wells in the latter districts have been driven with a plug in the pipes, and so no record of the beds passed through is available. The evidence from the first three places in conjunction with that from the Christchurch area proves the former presence of a strait passing round the western margin of Banks Peninsula, as suggested by Haast (1879, p. 400) on the evidence afforded by surface phenomena. This strait must have been a comparatively narrow one as there is no record of shells having been found further out on the plains than the places mentioned and the bores have been mostly through shingle. Thus there is no record of shells in the deep bore at Islington (732 feet) which is about 8 miles north-west of the base of the peninsula hills. However, the inter-stratification of gravels with marine deposits right up to their foot indicates that at times antecedent to the present the plains tied, or almost tied, the volcanic mass of the peninsula to the mainland. The gravels must have been laid down on a land surface or in immediate proximity to a beach, so that the gravels inter-stratified with marine beds indicate a former higher level of the land, while the sea-shells indicate an invasion of the sea as the land sank.

The shells which are found at a depth of 300 feet in the Christchurch area indicate either a deep sea, or, as is more probable since the mollusc is a shallow water form—a progressive lowering of the land, so the alternation of land and sea over the area, evidenced by the inter-stratification of land and marine beds, was repeated several times. Some of the shells brought up from the artesian wells are very stout in substance, and this is a feature shown by shells living on open beaches. So it is probable that the water where they lived was not very well sheltered, and therefore there was no effective protection against the seas sweeping up from the south round the western side of the peninsula. The closing of the southern entrance to this strait by the Ellesmere Spit no doubt took place during a period of relative still-stand of the coast, when the depth of water to the south of the peninsula was such that the transport of material could take place across the strait, and the drift did not follow the line of its western margin. This depth might have been due to change in level of the land or to the progradation of the shore line. It is unlikely that the depth of water at this time exceeded 30 feet, that is, the approximate thickness of the gravel forming the spit.

The fact that the land was much higher than at present within fairly recent times is evidenced by the coastal features of Banks Peninsula. The drowned valleys which mark the whole seaward fringe, and the alluvium-filled valleys facing the plains all demand a

lowering of the land to account for them. No precise determination of the amount of lowering that has taken place can be made from considerations affecting them, except that the minimum amount must be measured by the depths of the seaward end of the valleys. Now the depth of water at the entrance to Akaroa Harbour is 18 fathoms, so there must have been a minimum subsidence of the land amounting to just over 100 feet, but this estimate does not allow for the fact that the harbour may be partly filled with sediment washed from the neighbouring hills, or that the land may have extended some distance further seaward. The only occurrence that I know of where the depth of alluvium has been determined is in the case of the valley behind the town of Sumner where, on boring for water, solid rock was struck at a depth of about 200 feet, so that there is thus indicated a further amount of subsidence. This submergence must have taken place before the spit was constructed. I cannot see any evidence for the additional submergence of 800 feet postulated by Jobberns (1928, pp. 556-7). The presence of a level shelf over half a mile broad on the northerly slope of Mount Herbert, if due to wave action must have taken a long time to form, and the absence of similar shelves in the neighbourhood where they should occur, especially on the southern slopes of the Peninsula, makes me view the conclusion with suspicion. It seems to me far more probable that this flat surface is determined by the hard layer of basaltic rock which forms its floor. Then again if the waves have cut this bench, why is there an entire absence of any trace of benching on the spur on the opposite side of the Charteris Bay Valley. The presence of the ridge on the western side of Gebbies Pass of height somewhat accordant with the shelf on the western side of Charteris Bay appears to me a mere accident. The top of this ridge is formed by the highest exposure of the underlying substratum of greywacke and related rocks, while the steeper ground to the west is formed of the overlying volcanics. There are no benches or beaches at accordant levels on the southern facing of the peninsula such as might have been expected had the land stood still long enough for a shelf to be cut back a distance of over half a mile in the comparatively sheltered waters of the northern side of Mount Herbert. In any case a shore platform should also be accompanied by a train of phenomena and in the absence of any of these, or of all but one, a conclusion as to its existence must be viewed with suspicion. Further, if the land had been depressed till this bench was submerged all the loess which caps the spurs on the southern side of the peninsula should have been removed unless the time of the depression is moved back to pre-glacial, that is, to pre-Pleistocene times, and also there should be signs of long still-stand of the land at the 800 foot level on the Canterbury Plains and on the foot-hills adjacent thereto—but these are entirely absent. Even if the shore platform were cut in pre-glacial times some traces of it should be in existence, especially as the last phase of the glaciation was posterior to the formation of the plains, for moraine lies on top of the gravels at the Rakaia Gorge and in the Ashburton Valley.

I must also express my present disagreement with a suggestion of my own advanced many years ago (1908, p. 32), that the ends of the spurs reaching down on the southern side of Banks Peninsula

owed their flat extremities to marine erosion when the land stood at a lower level. I am sorry that I must apply the same test as given above and conclude that there has been no definite submergence and subsequent uplift of the coast to the extent demanded by the height of the ends of the spurs. I submitted my original contention to Professor W. M. Davis when he was on a visit here, and he said that he saw no evidence of this submergence, and the subsequent uplift, nor does he mention the point in his recent work on Coral Islands, although he takes Banks Peninsula as one of his types of depressed and eroded islands (1928, pp. 151-4). It seems more satisfactory to attribute the flat terminations of the spurs to the existence of a flat or flatter capping of hard rock, such as does occur on the outskirts of the volcanic mass, especially where the lavas are fluid as basalts usually are. There are no beaches on these flat spurs to support the contention that the land form is due to marine erosion. The covering of loess would naturally be deposited when the land was at a higher level and there has been no depression to wash this off since it was blown from the front of the glaciers and from the streams issuing from them in Pleistocene times.

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NOTE.—Since writing the above, Mr. Jobberns has drawn my attention to the existence of greywacke pebbles on the top of a stack on the east side of the outlet of Lake Forsyth. I have examined the spot and also the cliffs in its vicinity, and find that the stack and cliffs are covered with a deposit of typical loess and the pebbles either rest on this or in some few cases are perhaps included in it. The latter cannot be demonstrated for certain, but clear-cut banks of loess show no included pebbles and the few that are apparently included may have been washed down from above and been caught in loess material which has also slumped, thus giving the impression that they are included. The pebbles are of the ordinary beach type of the neighbourhood, and are exclusively of greywacke, quartz, and jasperoid rock. They range in size from three inches downward, but the pebbles at higher levels are usually small. The number is greatest at the lower levels and none occur higher than 200 feet above sea-level. There are at last two Maori ovens with burnt stones in the area looked at.

Now it might, at first sight, be assumed that these pebbles represent an old beach, and that the land was at one time at least 200 feet lower in level, but there are objections to this conclusion. First of all, there is no definite deposit showing the structure of a beach, nor

is there any eroded shore platform on which it might rest. If this had been the case, the pebbles should have been formed of the country rock, a basalt or basic andesite, and although pieces of this do occur they are not beach-worn at all. There is also the objection, that had the land been 200 feet lower, then all the present spit would have been submerged to a depth of at least 25-30 fathoms, and the sea would have extended over a wide belt of plain to the west. It would then have been impossible for greywacke pebbles of the beach type to have been transported across such a belt of sea, at least 25 miles wide, in the numbers that actually occur, as taking into account their only possible source they must have been. The pebbles should have been of Banks Peninsula origin had they been a beach deposit. On the end of the spur terminating in the Devil's Knob there is a capping of loess, and in this at a height of nearly 300 feet are very small quartz and jasperoid pebbles, never more than an inch in diameter and in very small numbers. These might conceivably have been blown to the position where they occur, or they may have been derived from the heaps of moa gizzard stones, which they most closely resemble, the remains of moa bones being also a characteristic content of the loess. If there had been any definite beach on the hills close to Lake Forsyth, similar deposits should occur on the hills to the west, and all I can find are occasional small pebbles either on or in the loess. The ends of these spurs also show signs of having been occupied by the Maoris as ovens occur frequently. Further west still they are increasingly scarce and finally do not appear at all. So I must conclude that they were not deposited in that situation by the sea, but carried there by adventitious means. All the same I am not prepared to say what this is, except that it is conceivable that heavy seas may have been responsible for some of them near the present coastline, wind for some of the smaller ones; and also, since these spurs were formerly inhabited, that they may have been carried to their present position by man himself.†

If they have been deposited in the position where they now lie by the sea, and some of them are really included in the loess, then it again opens the question as to whether the loess is a silt deposit, as maintained by Hutton, or a land deposit as maintained by most other authorities, including Haast and Heim.

Appendix on the Plant-covering of the Spit.

By A. Wall.

The general character of the plant-covering of the Ellesmere Spit is determined by (a) the edaphic conditions, particularly the poverty and scantiness of the soil, which is either pure sand or a sandy gravel; (b) exposure to the sun, which is at a maximum; (c) exposure to wind, which is also at a maximum; and (d) proximity to the sea. These conditions have produced a vegetation which is markedly xerophytic with a halophytic element. In the immediate neighbour-

†I have recently seen pebbles on Karewa Island near Tauranga, high above the sea, whose presence at that level I could not account for.

hood of the sea we find a typical dune vegetation, while further back the plant-covering is almost identical with that of the lower parts of the great riverbeds, e.g. of the Waimakariri or the Rakaia. The area is dealt with by Cockayne, in Vegetation der Erde (1928) under the head of "Beach of loose stones."

Though the soil is shallow and poor there is a very fair growth of grass and common pasture plants, both native and alien. *Poa caespitosa* is dominant over the greater part of the area, but not, of course, quite close to the sea. Associated with this are *Stipa setacea, Festuca littoralis, F. novae-zealandiae, Carex lucida, C. breviculmis,* and *C. resectans, Dichelachne crinita* (a small form), *Danthonia pilosa, Scirpus nodosus, Leucopogon Fraseri, Vittadinia australis, Gnaphalium luteoalbum, Acaena microphylla,* and *A. novae-zelandiae, Cotula squalida, Erechtites quadridentata, Geranium sessiliflorum, Raoulia lutescens* and *R. Monroi, Muehlenbeckia ephedrioides, M. axillaris,* and *M. complexa, Triodia exigua, Carmichaelia Monroi,* and *C. subulata, Scleranthus biflorus, Pimelea prostrata, Hymenanthera crassifolia, Pteridium aquilinum, Cheilanthes Sieberi.* Shrubs are represented by *Discaria Toumatou* (chiefly upon the raised bank which runs the whole length of the Spit (see Plate 29), *Carmichaelia subulata, Clematis afoliata, Sophora tetraptera, Hymenanthera crassifolia,* The dune area close to the sea is occupied by *Scirpus frondosus, Calystegia Soldanella, Carex pumila, Phormium tenax* (very scarce), a stunted form of *Myoporum laetum,* and a few exotics such as *Hypochaeris radicata* and *Rumex acetosella.* Immediately behind the dunes there are very dry barren patches and hollows chiefly occupied by *Raoulia lutescens,* and strong cushions of *Pimelea laevigata. Pteridium aquilinum* also grows very near the sea in some spots.

The principal exotics are Clovers, Rye-grass, *Bromus* sp., Thistles, Haresfoot Trefoil, Salad Burnet, Nettle, *Erodium cicutarium, Verbascum thapsus, Polycarpon tetraphyllum, Avena fatua, Lepidium murale,* and *Marrubium vulgare.*

The most remarkable single species of the locality is the prostrate form of *Carmichaelia subulata,* called by Cockayne an "epharmone" of that species. This really exists in three fairly well marked forms or grades. Sometimes it is perfectly prostrate, the single plant forming a circular patch about six feet in diameter, but all branches proceeding from one stem without any tendency to root in creeping. Many such plants are often grouped together, forming great patches twenty feet or more in diameter, the individual plants being closely matted together, and the whole mass rising to about two feet above the ground. Then there are intermediate forms, from two to three feet in height, not truly prostrate yet not as tall and erect as the species usually is. And there are also plenty of plants which grow to six feet or more in height and are in every way perfectly normal representatives of the species. All these forms differ from the typical plant, if at all, in the manner of growth only, and a close examination of the prostrate forms failed to detect anything, either in the soil or in the aspect or provision of shelter, which could at all suggest a reason why particular individuals should assume the one form rather than the other. The extreme prostrate form is of course due to wind-pressure.

The Metamorphic and Ultrabasic Rocks of the Lower Cascade Valley, South Westland.

By F. J. TURNER, Otago University.

[*Read before the Otago Institute, 3rd December, 1929; received by the Editor, 13th February, 1930; issued separately, 29th May, 1930.*]

PLATES 34–38.

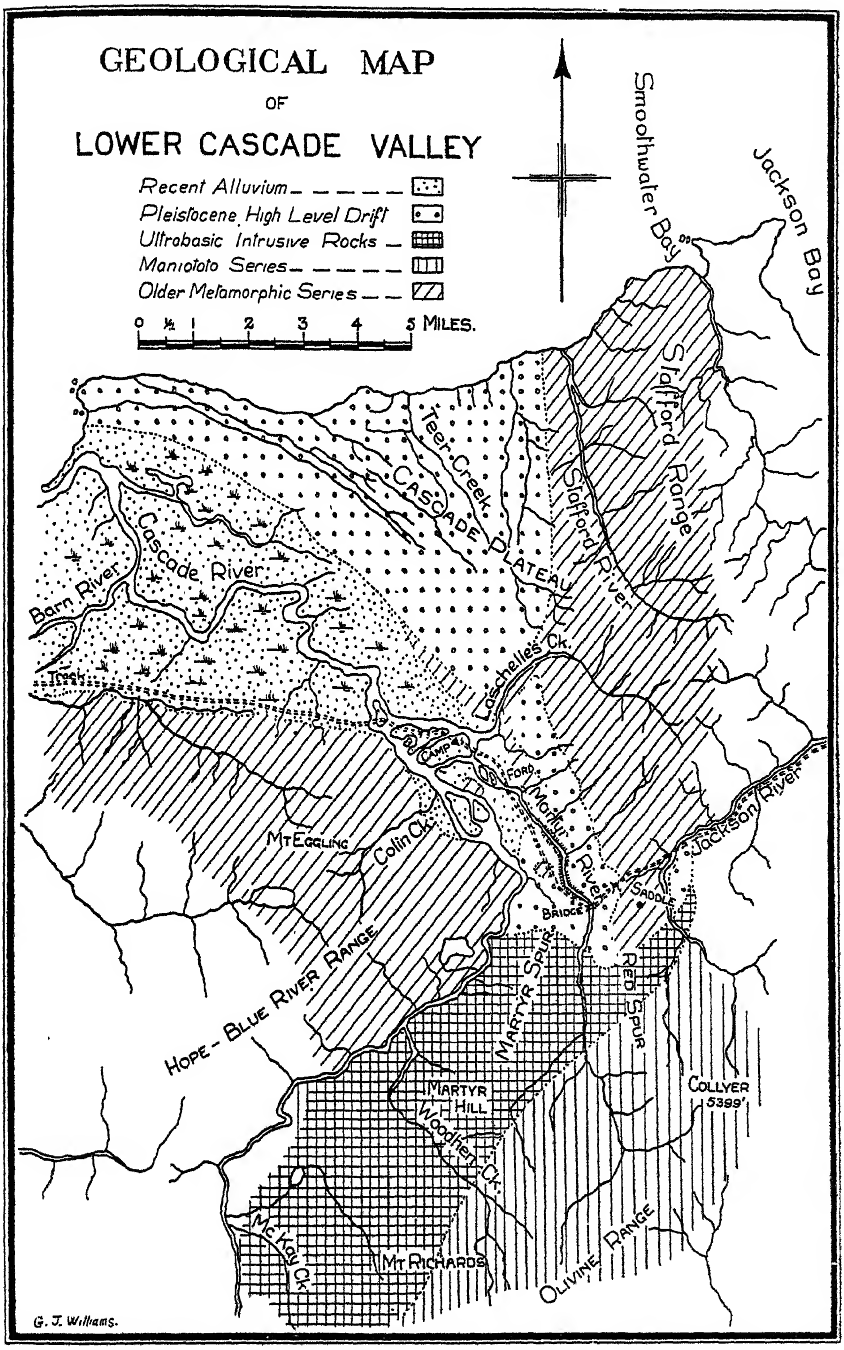
CONTENTS.

INTRODUCTION.

THE area to be described embraces about fifty or sixty square miles of country in the vicinity of the lower part of the Cascade Valley, South Westland, and includes parts of the Cascade Plateau and the Hope-Blue River Range, and the western slopes of the northern portion of the Olivine Range.

In January and February, 1929, the writer, accompanied by Mr. W. E. La Roche of Auckland, and Mr. G. J. Williams of Dunedin, visited this region, the greater part of the expenses incurred being met by a Government research grant from the New Zealand Institute.

The route followed lies from Makarora at the head of Lake Wanaka, over the Haast Pass, down the valley of the Haast to the coast and thence ten miles southward to the isolated settlement of Okuru. From Okuru the track follows down the coast across the Waiatoto and Arawata rivers, up the Jackson from its junction with the Arawata to the low saddle which leads into the valley of Martyr Creek, and so into the lower part of the Cascade Valley. Here a camp was established in the excellent hut belonging to Nolan


GEOLOGICAL MAP
OF
LOWER CASCADE VALLEY
Recent Alluvium
Pleistocene High Level Drift
Ultrabasic Intrusive Rocks
Maniototo Series
Older Metamorphic Series
0 ½ 1 2 3 4 5 MILES.
Smoothwater Bay
Jackson Bay
Stafford Range
Teer Creek
CASCADE PLATEAU
Stafford River
Cascade River
Barn River
Track
Laschelles Ck.
CAMP
FORD
Martyr River
Jackson River
SADDLE
BRIDGE
Mt Eggling
Colin Ck.
Hope-Blue River Range
Martyr Spur
Red Spur
Collyer 5399'
Martyr Hill
Woodhen Ck.
McKay Ck.
Mt Richards
Olivine Range
G. J. Williams.

Brothers of Okuru, and subsequent field work was carried out from this as a base. The total distance from Makarora is about 110 miles, which can be covered in four days of actual travelling (whether riding or walking). The track is on the whole good, but considerable difficulty may be experienced if the large rivers such as the Haast, Arawata and Waiatoto, or the smaller, though scarcely less formidable torrents, such as the Jackson and Martyr should be in flood.

The writer's party was unfortunate in encountering particularly bad weather; and heavy floods, combined with fog, rain and snow on the high country rendered it impossible to carry out detailed field work, and considerably limited the area that was geologically explored. It is hoped, however, that further exploration work at some future date will make possible a more detailed account of the field occurrence. The present paper is concerned chiefly with the petrological features of the rocks obtained. The discussion of the complex physiography observed is deferred to a later occasion.

The writer's sincere thanks are due to his two companions Messrs. La Roche and Williams, to Mr. P. Nolan of Okuru and his bushmen, for their generous hospitality and assistance, to Professor J. A. Bartrum of Auckland for help in connection with photomicrographic work, and especially to Professor W. N. Benson of Otago University for his advice and valuable assistance in the preparation of this paper.

Previous Work.

The earliest report is that by Cox (1877), who described briefly the small area of Tertiary rocks in the vicinity of what was then the settlement of Jackson's Bay.

In the same year there also appeared a brief report by Mr. D. Macfarlane, then Government Agent at Jackson's Bay (Macfarlane, 1877), on the geology of the valleys of the Jackson and Cascade, in which a large belt of ultrabasic intrusive rocks was described and accurately mapped. In an accompanying note by Hector (1877) identifications of the rocks collected by Macfarlane were given.

In 1886, Professor Park, then geologist in the Government Geological Survey, carried out an extensive exploration of the rugged and still almost unknown country which lies between the upper reaches of the Dart and the head of the Cascade Valley. In this report (Park, 1887), an account is given of the southern portion of the peridotite instusion, where it attains its maximum development in the vicinity of Red Mountain.

Ulrich (1890), published an account of the ultrabasic rocks of Red Mountain and the Cascade River, in connection with the occurrence therein of the new iron-nickel alloy awaruite which had recently been described by Skey (1886). This account and the map accompanying it, were based on specimens received from various prospectors, and especially upon information supplied by Mr. R. Paulin, who for many months was engaged in prospecting and exploration along the whole length of the peridotite belt. Unfortunately, however, the geological features shown on the northern part of this map—representing the area dealt with in the present paper—have proved to be incorrect in many instances.

SYNOPSIS OF GEOLOGY.

The oldest rocks in the area appear to be a series of intensely metamorphosed sediments, represented by gneisses, schists and hornfelses, invaded by innumerable dykes and veins of granite-pegmatite and granite. These rocks, which will henceforward be referred to as the Older Metamorphics Series, are developed extensively on both sides of the lower portion of the Cascade Valley, in the Hope-Blue River Range on the south, and to the north in the bush covered ranges which lie between the Cascade Plateau and the valley of the Jackson.

Corrugated quartz-mica-schists, petrologically identical with the schists of Central Otago (Maniototo Series of Park), form the crest of the Olivine Range along the Cascade-Arawata Watershed, on the eastern border of the map. For reasons which will appear later, these are considered possibly to be younger than the rocks of the Older Metamorphic Series, and they are here correlated with the Central Otago schists with which, indeed, they are almost certainly continuous across the dividing range. It has recently been shown (Marwick, 1925) that these latter rocks are not younger than Carboniferous, and possibly extend far back into the Palaeozoic.

Serpentines and peridotites and associated dyke-rocks form a north-east and south-west trending belt, which lies along the lower slopes and spurs of the western flank of the Olivine Range, between the Older Metamorphic Rocks on the north-west and the schists which form the summit of the Olivine Range on the south-east. These intrusive rocks appear to be younger than either of the series of metamorphic rocks, and are possibly to be regarded as of Early Cretaceous age.

Limestone, marls, sandstones and conglomerates of Middle Tertiary age have been described by Cox (1877) as occurring near the old (now abandoned) settlement of Jackson's Bay, where they constitute a small patch lying unconformable upon the ancient basement rocks. Park (1887) mentions similar small remnants of a former Tertiary cover at Big Bay, some 35 miles south, but as neither of these occurrences was examined by the present writer the rocks of this series will not here be considered further.

The youngest rocks in the area are those of Pleistocene and Recent age, including drift material and alluvium, which are developed extensively for a distance ten miles inland from the mouth of the Cascade, and on the Cascade Plateau immediately north of this.

The downward sequence may, then, be summed up as follows:

(5) Alluvial, glacial and fluvioglacial detritus (Recent and Pleistocene).
(4) Limestones, marls, sandstones and conglomerates (mid-Tertiary).
(3) Peridotites, serpentines and accompanying dyke rocks. (? Early Cretaceous).
(2) Schists of the Maniototo Series (Palaeozoic).
(1) Older Metamorphic Series (? Pre-Maniototo).

The Older Metamorphic Series.

Distribution.

The rocks of the Older Metamorphic Series are developed extensively on both sides of the lower part of the Cascade River, where it flows north-west to the sea.

From the fact that all the boulders in the bed of Colin Creek, which drains the north-eastern slope of the Hope-Blue River Range, consist of rocks of this type, it is inferred that they make up at least the northern end of the range, though the whole of this area was mapped by Ulrich (1890) as peridotite. These hills moreover are heavily bushed (a fact which in itself points to the absence of much peridotite), and owing to the difficulty of fording the Cascade, which was almost constantly in flood, they were not examined in detail. From observations made from the western slopes of the Olivine Range it appears certain, however, that the metamorphic rocks continue for a considerable distance up the north-western side of the Cascade River, which here flows north-east along the junction with the peridotite mass. This accords with Macfarlane's map (1877) on which the north-western boundary of the ultrabasic rocks is marked by the Cascade River along the whole of the north-easterly portion of its course from McKay Creek down to the point where it turns abruptly through 90° and flows north-west to the sea.

On the north-east side of the Lower Cascade, banded gneisses are well exposed in the steep sides of the gorges cut by Laschelles Creek and the small creeks which drain into the Martyr, between this and the ford across the latter stream. Similar rocks appear to underlie the whole of the vast mass of alluvial and morainic material which mantles the Cascade Plateau, and probably extend at least as far north as Jackson's Bay. The precipitous gorge of the Martyr River has also been carved in cemented stratified conglomerates overlying the Older Metamorphic Rocks. These latter appear in the lower part of the walls of the gorge, as well as at the south end of the bridge which spans it, where coarse biotite-sillimanite-gneisses and large veins of granite-pegmatite are very clearly exposed. Isolated masses of grey quartz-biotite-gneiss invaded by numerous veins of pegmatite outcrop prominently from beneath the mantle of Pleistocene conglomerate at a number of points along the track between the Martyr Bridge and the ford about three miles downstream.

The rocks of the Older Metamorphic Series were traced through the bush which covers the western ends of Martyr Spur and Red Spur to their termination against the peridotite mass. The actual junction is well below the bush line and was not therefore observed.

The northern limit of the gneissic rocks was not determined owing to the unfavourable weather conditions experienced along the route from the Arawata to the Cascade Hut, but such observations as could be made suggest that these rocks probably extend as far north as the Arawata.

Petrography.

(1.) *The Gneisses, Schists and Hornfelses.*

Gneisses of the older series are exposed abundantly along the track on both sides of the bridge across the gorge of the Martyr. Numbers 1200 and 1201 are fine-grained compact gneisses with no trace of banding, light green in colour, showing in the hand specimen numerous cleavage faces of small feldspar and mica crystals. In thin section they consist essentially of quartz 50%*, feldspar 25% to 30%, biotite and chlorite 15% to 20%, and a little muscovite. The quartz is in highly irregular interlocking grains averaging 0.5 mm. to 1 mm. in diameter, frequently elongated in directions parallel to one another, and invariably showing pronounced undulose extinction (Fig. 4). The feldspar is largely andesine with subordinate orthoclase, both considerably altered to kaolin, in grains reaching 1 mm., in average dimension. The biotite is reddish brown, strongly pleochroic, in flakes of similar size scattered evenly throughout the rock. In number 1200 it is almost completely replaced by a green almost isotropic chlorite; but in number 1201 the two minerals are present in equal proportions, the biotite occurring as a central unaltered core surrounded by a border of chlorite, though in a less altered part of the section chlorite is practically absent. Muscovite is present in sparse, large, ragged flakes up to 2 mm. in length, and often contains rounded grains of included quartz. Apatite is an abundant accessory in small prisms and rounded grains, while a few very small short prisms of brown tourmaline and tiny patches of magnetite were also noted.

Numbers 1202 (Fig. 1) and 1203 represent a coarse gneiss developed at the southern end of the bridge adjacent to small invading dykes of pegmatite. In hand specimen the rock is irregularly banded, and is seen to consist of layers a few millimetres thick, rich in brown biotite, alternating with lensoid bands of quartz and white feldspar, averaging 5 mm. in thickness, which appear to have been introduced from the adjacent pegmatites. In one instance a single mass of feldspar, 50 mm. through and in crystalline continuity throughout, was observed occurring in this way. At the junction with the pegmatite the gneiss is especially rich in coarse biotite. In thin section the rock is seen to consist of quartz 40%, feldspar 25%, biotite 20%, muscovite 5%, and sillimanite 5% to 10%, with accessory apatite and magnetite. The quartz occurs in large clear interlocking grains about 2 mm. in diameter, with marked undulose extinction. The feldspar is oligoclase-andesine, possibly accompanied by a small amount of orthoclase, in irregular grains of the same order of size as the quartz, slightly clouded by kaolin, and sometimes containing as inclusions rounded grains of quartz. Twinning according to the albite law is common, but may be quite absent, while pericline twins are rare. Biotite occurs as large, ragged or subidioblastic crystals up to 3 mm. in length showing very strong pleochroism from pale yellowish brown to very deep reddish brown. It

*Unless otherwise stated the percentages given are rough estimates based upon microscopic inspection.

is usually quite fresh, except in part of one section (number 1202) where there is incipient alteration to chlorite. Muscovite occurs sparingly in large irregular flakes, often with bent cleavage lamellae and undulose extinction. Sillimanite occurs plentifully in long, slender, transparent prismatic crystals which reach up to 2 mm. in length, usually in aggregates of parallel individuals. It may be distinguished easily by its high refractive index, moderately high double refraction (giving bright interference tints), straight extinction, positive elongation and well defined cross fracture. It occurs scattered through crystals of biotite, or of quartz, or very frequently along the margins of crystals of biotite. In some parts of the section (Fig. 16) aggregates of parallel prisms of sillimanite have apparently replaced almost completely crystals of biotite, remnants of which still persist throughout rendering the whole mass pleochroic in pale brownish tints. Similar replacement of biotite by sillimanite has recently been described by C. M. Tattam (1929) in schists and gneisses from north-east Victoria. In other instances, however, the boundary between biotite and sillimanite is sharp, while in many parts of the section the prisms of sillimanite are enclosed by quartz or feldspar and are obviously unrelated to biotite. Apatite is present in large crystals (1 mm. $\times$ 0.2 mm.) included in the quartz, feldspar or biotite, while accessory magnetite is also present, especially as inclusions in the biotite.

Specimens collected from beside the track about one mile south of the bridge* consist of a fine-grained compact banded grey or greenish gneiss very similar to that already described from the vicinity of the bridge (numbers 1200-1201). The constituent minerals are quartz 45%, feldspar 30 % (including variable but approximately equal proportions of andesine and orthoclase), biotite, or chlorite derived from it, 20%, muscovite 5%, together with magnetite, apatite and small prisms of brown tourmaline as constant accessories. The biotite of the fresh rock (numbers 1204 and 1205) is deep reddish brown and shows no sign of alteration while the feldspar is only slightly kaolinised (Fig. 2); but in some apparently altered specimens, especially in the finer phases of the rock, the biotite may be replaced partially (Number 1206) or completely (Number 1207) by chlorite which imparts a greenish colour to the hand specimen, while the feldspars in such cases show considerable alteration to kaolin. Muscovite is not plentiful and occurs in rare rather large, ragged crystals, which frequently enclose rounded inclusions of quartz. Though the grain becomes considerably coarser where close to the contacts between the gneiss and the numerous dykes and veins of pegmatite which here invade it, they never approach in coarseness the banded gneisses (such as Numbers 1202 and 1203) which have been described above from near Martyr Bridge.

Sections 1208, 1208a and 1208b represent a regularly banded, very compact gneiss which occurs abundantly *in situ* in the sides of the steep gorge which has been cut by the small creek which drains

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*The gneiss of this locality is so crowded with veins of pegmatite that the whole mass might be described as a "lit-par-lit" gneiss.

southward into the Martyr just below the ford across the latter stream. The bands, alternately coarse and fine, are about 30 mm. or more in thickness and are very sharply defined. The fine bands (Number 1208a) consist of quartz 40%, feldspar 25%, biotite 25%, muscovite 10%, and accessory tourmaline and apatite. Quartz is present as interlocking clear allotriomorphic grains, with undulose extinction, averaging 0.2 mm. in diameter. The feldspar is in untwinned grains of similar size, and may be distinguished from quartz by its definitely lower refractive index, and by the slightly clouded appearance of the crystals. Such interference figures as could be obtained in spite of strain effects indicate that the mineral is positive, and on this account, and since the refractive index appears to be only slightly lower than Canada Balsam, it is probable that the feldspar is oligoclase-albite rather than orthoclase. Biotite is plentiful in large, pleochroic, deep sepia brown crystals (0.5 mm. to 1 mm.) which have a marked tendency towards sieve-structure due to rounded inclusions of quartz and less commonly crystals of muscovite. Muscovite, in small idioblastic flakes up to 0.3 mm. in length, is scattered abundantly through the rock, usually between the crystals of the other minerals. The optic axial angle is small, and basal sections show undulose extinction and quite low order interference tints between crossed nicols. Whereas the crystals of biotite are oriented parallel to the banding of the rock, those of muscovite show no approach to parallel orientation. Tourmaline, with marked pleochroism from pale yellowish to deep brown tints, is an abundant accessory mineral, occurring in stout prisms or rounded grains which may reach 0.3 mm. in length, while similar crystals of apatite are also plentiful. In section 1208b cut from a coarse band in the same rock the mineral composition is similar to that just given for the finer band, except that feldspar is present to the extent of only about 5%, the quartz being correspondingly increased to over 50%, while muscovite is slightly more plentiful. Crystals of biotite are larger (1.5 mm.) and show very perfect sieve-structure (Fig. 3) where they enclose numerous rounded grains of quartz and sometimes small crystals of muscovite. In two cases the cleavage lamellae show bending and distortion due to pressure. Muscovite, tourmaline and apatite are developed much as in the finer phases of the gneiss. In section Number 1222 the contact of the gneiss with a vein of tourmaline-pegmatite is shown. The line of separation is definite and sharp, but the gneiss immediately bordering the pegmatite is especially rich in small flakes of muscovite arranged parallel to the contact, while there are several large idioblastic crystals of brown tourmaline about 2 mm. in length showing perfect sieve-structure with numerous inclusions of quartz. Some of the biotite has been converted to pennine pseudomorphs, but some remains unaltered.

Muscovite-biotite-quartz-schist (Numbers 1209, 1209a) is well exposed in the small island in the Cascade River a mile or so above its junction with the Martyr. The rock is compact, but the predominance of the micas over quartz gives it a well marked schistosity unusual in the rocks of this series, while veins of secondary quartz are frequent. A section at right angles to the schistosity shows

small plates of muscovite making up 50% of the rock, clear quartz 20% (in grains from 0.1 to 0.2 mm.) scattered through the felt of muscovite crystals, and about 30% deep brown biotite in large crystals about 1 mm. × 0.5 mm., in some of which sieve-structure is visible. Apatite and brown tourmaline occur as accessories.

The rocks forming the north-eastern face of the Hope-Blue River Range are represented only by specimens collected from boulders in the bed of Colin Creek (Numbers 1210, 1210a, 1211, 1212, 1213, 1213a). Sections 1210 and 1210a were cut from a rather fine-grained quartz-biotite-muscovite-schist which is much less coherent than is usual in the rocks of this series. It consists of fine bands two or three millimeters in thickness alternately rich in quartz and in micas. Quartz with undulose extinction, deep brown biotite and muscovite are present in equal proportions, but crystals of biotite are much larger than those of the other minerals and show a tendency towards imperfect sieve-structure. As in nearly all the rocks of this type the muscovite is in small crystals 0.5 mm. × 0.05 mm., and has only a small optic axial angle, so that between crossed nicols basal sections show interference tints considerably lower than do the grains of quartz. Brown tourmaline, and to a less extent apatite, are abundant accessories as small prisms.

Numbers 1213 and 1213a (Fig. 16) represent the fine and coarse phases respectively of a compact banded gneiss, consisting of alternatively coarse and fine sharply defined bands which average from 7 cms. to 10 cms. in thickness. In the finer bands quartz (60%) and biotite (25%) make up the bulk of the rock, in crystals of variable size ranging from 0.1 to 0.7 mm. Small crystals of muscovite, partially kaolinised, occur to the extent of about 15%, while grains of epidote, prisms of brown tourmaline and apatite, and a little magnetite are present as accessories. In the coarser phase the same minerals are developed. Biotite is raised to 35% and occurs in large porphyroblasts 1 mm. long, strongly pleochroic in light yellowish to deep reddish and sepia browns, almost uniaxial, with well developed sieve-structure due to numerous inclusions of rounded quartz grains and of rare idioblastic muscovites. These are set in a fine mosaic—much finer and more even-grained than in the "fine" band described above—consisting of even-sized crystals and grains about 1 mm. in diameter of muscovite and quartz in the proportion of 2 : 1. The quartz has only a tendency towards undulose extinction.

Sections 1211 and 1212 were taken from a compact gneiss with very distinct alternating fine and coarse bands a few millimeters in thickness. The average composition of the finer bands is esssentially quartz 40% to 50%, feldspar 15%, and biotite 25% and muscovite in very variable proportions, usually from 5% to 15%. The quartz and feldspar are in small irregular grains averaging 0.1 mm. in diameter. All the feldspar is untwinned with a refractive index less than that of Canada Balsam, but the fact that the optical sign is sometimes positive and sometimes negative indicates the presence of both albite and orthoclase. The biotite is in ragged sepia brown crystals a little larger than the surrounding grains of quartz and feldspar; it is sometimes partially altered to greenish biotite and

chlorite, and often shows incipient sieve-structure. In the coarser bands quartz, feldspar and muscovite are developed much as in the finer phase of the gneiss, except that the latter mineral is usually more plentiful and the feldspar less abundant. The biotite, however, as well as being more plentiful is very much coarser, and occurs in large oriented diablastic porphyroblasts about 1 mm. × 0.5 mm., with numerous rounded inclusions of quartz. Andalusite is constantly present to the extent of about 10% in the coarser bands only, in large diablastic masses up to about 1 mm. or 2 mm., in diameter, enclosing almost an equal amount of quartz in rounded grains (Fig. 5). The high refractive index (higher than that of the biotite), fairly low birefringence (slightly greater than that of quartz), straight extinction parallel to a poorly marked cleavage, and negative elongation all agree perfectly with the normal properties of andalusite though it was not possible to obtain distinctive interference figures in convergent light. Some sections show the characteristic partial alteration of the mineral to muscovite. Throughout the whole rock brown tourmaline is an abundant accessory, together with prisms of apatite and grains of magnetite and rarer epidote.

Number 1214, cut from a pebble which was collected at the ford across the Cascade River immediately below its junction with the Martyr, is a lightcoloured greyish green hornfels in which quartz (60%), kaolinised feldspar (30%) and partially chloritised biotite (10%) are the chief constituents. Much of the quartz is in large ragged porphyroblastic grains about 0.7 mm. in diameter, set in a matrix consisting of much smaller grains of quartz and the other minerals. The biotite is mostly in small irregular deep brown flakes without inclusions, a large proportion being altered to pennine and other chloritic products. Small masses of kaolin, probably representing original feldspar, are abundant, while apatite and magnetite are present as accessories, along with rare grains of epidote which usually occur associated with the chloritised biotite. The section contains a single knot about 1 mm. × 1.5 mm., consisting of about six crystals of a mineral which is identified somewhat doubtfully as prismatine, the whole being fringed with a biotite (Fig. 6). The mineral is transparent, almost colourless but with a slightly yellowish tint, non-pleochroic, with high refractive index (probably between 1.65 and 1.70), and fairly high double refraction (about 0.016). The crystals are prismatic with negative elongation parallel to a single well marked cleavage, with reference to which there is a straight extinction. There are rare small inclusions of magnetite. Unfortunately definite interference figures in convergent light could not be obtained. The distinctly negative elongation distinguishes the mineral definitely from orthorhombic amphibole or pyroxene as well as from sillimanite. The double refraction appears slightly too strong for prismatine, the birefringence of which is about .013, though Winchell (1927, p. 250) comments upon the variability of the optical properties of this mineral.

Hornfelsic rocks also occur abundantly in the boulders of Laschelles Creek and among the detrital material of the Cascade

Plateau, from which many of the boulders in Laschelles Creek were themselves derived. Since the bulk of the boulders of the Plateau consist of dunite which appears originally to have been brought from the middle and upper parts of the Cascade Valley, it is probable that much of the hornfels, too, has been derived from rather distinct localities.

Many of these rocks resemble in appearance and composition the finer types of quartz-biotite-gneiss which outcrop near the Martyr Bridge and along the track a mile or so south of this. They are finer in grain, however, and exhibit no trace of schistosity (Fig. 7). A common type is a brownish hornfels (Numbers 1215 and 1216, Laschelles Creek) consisting of quartz 60%, small ragged flakes of brown biotite 25%, and the remainder of the rock small grains of muscovite, possibly with a little basic plagioclase. Abundant apatite and less plentiful epidote and magnetite are accessories. Number 1217 (Cascade Plateau) is a similar rock with, in addition to the above minerals, a small amount of green hornblende and twinned basic labradorite in grains about 0.1 mm. in diameter. A greenish grey hornfels (Number 1218) from Laschelles Creek consists largely of small crystals of quartz and chloritised biotite together with aggregates of kaolin representing original feldspar. The biotite is almost completely replaced by chlorite in which fine sagenitic needles of rutile are perfectly developed. Muscovite occurs in rather large clear crystals with numerous inclusions of quartz, while there is also about 5% of clear microcline in well twinned masses up to 0.5 mm., occurring interstitially among the grains of quartz.

From the descriptions given above it will be seen that the majority of the rocks of the Older Metamorphic Series are fine-grained gneisses and hornfelsic rocks with little or no trace of schistosity, in which quartz makes up 50% of the rock and biotite is always abundant, while muscovite and feldspar are also consistently present in considerable amount. The feldspar is usually plagioclase ranging from albite to andesine together with a less amount of orthoclase, though in one case a small amount of basic labradorite and in another microcline were observed. In rare instances andalusite (Number 1213) or sillimanite (Numbers 1202 and 1203) may be present in some quantity, but in the majority of the rocks examined there was no trace of these minerals. The constant presence of accessory brown tourmaline and apatite, in idioblastic prisms is a characteristic feature.

The texture of the rocks is normally granoblastic, though in some of the banded gneisses the crystals of biotite are much larger than those of the other minerals present, and show more or less marked parallel orientation and perfectly developed sieve-structure. In two specimens (Numbers 1209 and 1210) the rocks are distinctly schistose, these two sections being especially rich in muscovite, which is present to the complete exclusion of feldspar, as well as having the usual complement of biotite.

(2.) *The Pegmatites.*

Wherever the gneisses and schists of the Older Metamorphic Series were examined *in situ,* they were found to be invaded by numerous dykes and veins of white pegmatite and granite, ranging from an inch to two or three feet in width, and conforming to the foliation of the invaded rocks.

Specimens taken from alongside the track about one mile south of Martyr Bridge are holocrystalline granitoid rocks consisting essentially of quartz 20%, feldspar about 70%, and muscovite and biotite in varying but never very large amount. The quartz is in allotriomorphic often interstitial grains with pronounced undulose extinction, and is sometimes present as sparse rounded grains included in crystals of feldspar. The feldspars are microcline, oligoclase-albite and orthoclase in very variable proportions, the last named mineral never being very abundant. The microcline, which in some cases (e.g. Number 1219) may make up nearly 50% of the whole rock, is in clear unweathered allotriomorphic masses—often interstitial—with perfectly developed gridiron twinning (Fig. 8). The plagioclase is considerably altered to kaolin, so that it is not always easy to compare the refractive index with that of Canada Balsam. The refraction is generally definitely less than that of the balsam, however, and the mineral is always optically positive, while the extinction angle measured with reference to the twinning plane is about 10°. In many cases twinning is either absent or only indefinitely shown. In some specimens (e.g. Number 1220) this mineral makes up 60% or more of the rock. The biotite is deep reddish brown and strongly pleochroic and in some sections shows partial alteration to chlorite, while the muscovite is always in large flakes, often with bent cleavage laminae. Neither mineral is ever present in greater quantity than 5% or 7%. Apatite in stout prisms is sometimes abundant, while magnetite, epidote, zircon, and in one case (Number 1220) very long slender needles of rutile may also be present as accessories.

Number 1221, cut from a large vein of pegmatite invading coarse gneiss at the south end of Martyr Bridge, differs considerably from those described above. Quartz, in large allotriomorphic crystals ranging up to 2 mm., and showing undulose extinction, makes up 30% to 35% of the rock. Nearly all the feldspar is andesine with bent twin-lamellae, while there is also a small amount of orthoclase, both minerals being somewhat altered to kaolin. Partially chloritised reddish brown biotite (3%), muscovite (5%) in ragged flakes often with included quartz, and clear golden brown to very pale brown idiomorphic tourmaline (5%) in crystals reaching 3 mm. in length are the remaining essential constituents of the rock. Rare apatite, needles of rutile, and secondary iron ores associated with the chloritised biotite are present in accessory amount. The rock shows evidence of considerable crushing in the partial granulation of much of the quartz and some of the feldspar, in the undulose extinction of the quartz and in frequent bending of the plagioclase twin-lamellae.

Number 1222, from a vein invading the banded gneiss in the gorge of the creek draining into the Martyr just below the ford,

consists mainly of quartz 30%, oligoclase-albite 50%, and orthoclase 10%. Tourmaline is abundant in large idiomorphic prisms usually blue in the central part and brown round the margins, or else in small brown prisms. Muscovite occurs in flakes ranging up to 2 mm., while accessory apatite is present in small prisms. Biotite is absent. The only evidence of straining is the slightly undulose extinction of the quartz grains.

Number 1223 (Fig. 9) from a boulder in the Martyr River at the ford, is a different type of rock, consisting of orthoclase 80%, quartz 15%, a small amount of oligoclase, a little muscovite and rare small flakes of chlorite pseudomorphous after biotite. The rock has been severely crushed and large strained and shattered feldspar and quartz crystals alike are set in a much crushed matrix of the same minerals which constitutes 20% of the rock.

The rocks described above may be summed up as a series of granite-pegmatites consisting chiefly of feldspar and quartz with only a small percentage of ferro-magnesian silicates in the form of either biotite or tourmaline. The feldspar is normally a mixture of potash-feldspar (orthoclase or microcline or both) and highly sodic plagioclase in very variable proportions, either mineral being sometimes dominant almost to the exclusion of the other. In one case (Number 1221) andesine is the dominant feldspar and the rock approaches a granodiorite-pegmatite in composition. Strain structures are sometimes very pronounced.

Origin.—From the summary given on page 174 it will be seen that the rocks of the Older Metamorphic Series are fairly uniform in composition and fall into Grubenmann's group of "alkali-feldspar gneisses." The rocks belonging to the biotite-rich families of this group are usually derived, according to Grubenmann 1910, pp. 147, 153), from the metamorphism of granites and syenites, or less commonly of sediments such as arkoses, breccias, and clays, of similar composition. Several lines of evidence sugggest, however, that the rocks considered in this paper were originally sedimentary rather than igneous. Chemical analyses have not been made, but the mineralogical composition indicates the high silica, relatively high iron and magnesium, and low calcium content characteristic of the sedimentary gneisses of this type (Grubenmann *loc. cit.*, p. 147). The abundance of both micas also points in this direction for Grubenmann (*loc. cit.*, p. 153) also notes that the meso-gneisses of this group are specially rich in micas when of sedimentary origin. Further the occasional occurrence of andalusite or sillimanite in some quantity indicates the excess of aluminium which is such a characteristic feature of the more pelitic types of sedimentary gneiss. Finally the clear cut nature of the junction between adjacent fine and coarse layers in banded rocks such as Number 1208 and Number 1213 suggests differences in texture and composition in original sedimentary strata, while the universal absence of all traces of blastogranitic structure in the thin sections seems also to preclude the possibility of igneous origin. It seems probable therefore that the rocks of the Oder Metamorphic Series

are the result of metamorphism of sedimentary strata which probably consisted originally of impure feldspathic sandstones.

The coarse grain size and completely recrystallised state of the constituent minerals, the prevalence of granoblastic structure, the universal abundance of deep reddish brown biotite and the invariable absence in the unaltered rock of chlorite, epidote or zoisite, all indicate that the rocks of the Older Metamorphic Series have attained a high grade of metamorphism and belong either to the meso- or middle zone or to the kata- or deepest zone of Grubenmann (*loc. cit.*, pp. 80, 81). Features indicative of the lowest zone are the granoblastic and hornfels structure of many of the rocks, the perfect development of sieve-structure in the larger crystals of biotite, and the occurrence of sillimanite and prismatine. The last two minerals are, however, rare in the rocks of this series, and their presence may be explained (see below) as the result of contact action due to the invasion of the series by granite-pegmatites. On the other hand, the occasional development of marked schistosity (Numbers 1209 and 1210) and the frequent presence of abundant muscovite which often constitutes 20% and in one case even makes up 50% of the whole rock, are features both of which are characteristic of the middle zone. The absence of garnet is not of any great significance in the rocks of this group (Grubenmann, *loc. cit.*, pp. 144, 149). It is probable, therefore, that the majority of the rocks of this series should be classed in the lower part of Grubenmann's middle zone in the family of meso-mica-alkalifeldspar–gneisses.

It seems certain, also, that the granite pegmatites which everywhere invade the rocks of the Older Metamorphic Series as innumerable small dykes and veins have had a not inconsiderable influence upon the invaded rocks. This effect is especially pronounced in the coarse sillimanite-gneiss of Martyr Bridge, which undoubtedly owes its large grain-size and peculiarities of mineralogical composition to complete recrystallisation of the normal quartz-biotite-feldspar-gneiss (into which it merges in the course of a few feet) in the presence of igneous material from the adjacent pegmatites, which has thoroughly permeated the surrounding rocks. Part at any rate of the sillimanite seems to have been formed by the replacement of coarse biotite, much as has been described by Tattam (1929, pp. 19, 45) in certain of the metamorphic rocks of north-eastern Victoria, where "the phenomenon occurs in schistose sedimentary material either in direct contact with or close to magmatic solutions." Probably much of the coarse muscovite and very coarse oligoclase-andesine of the Martyr Bridge gneiss is also due to recrystallisation of the original rock while thoroughly permeated by igneous solutions derived from the pegmatite. In other cases, e.g. one mile south of Martyr Bridge, the mica is coarsest and most plentiful near the contact with pegmatite veins. The universal presence of idioblastic brown tourmaline and of apatite throughout all of the Older Metamorphic Rocks would also suggest that these minerals have been formed under the influence of magmatic emanations from the pegmatites penetrating through the gneiss. The pegmatites themselves carry abundant brown tourmaline in many

cases, and the surrounding rocks then appear to be specially rich in tourmaline near the contacts. Finally the occurrence of undoubted andalusite in one rock is also evidence of contact action, and probably is the result of high temperature induced in the vicinity of a mass of pegmatite.

The effects of retrogressive metamorphism at a later stage in the history of the area are to be seen in the tendency for biotite to give place to chlorite in some of the rocks, the frequent undulose extinction in crystals of quartz and feldspar in both gneisses and pegmatites, and occasional bending of biotite and muscovite laminae. That the chlorite has developed from biotite and not *vice versa* is definitely shown by the presence of webs of sagenitic rutile in the chlorite, representing titanium in the original biotite, by the frequent occurrence of borders of chlorite surrounding cores of unaltered biotite, and by the obviously pseudomorphous nature of much of the chlorite. Cataclastic structures in many of the pegmatites themselves show that the whole series including both pegmatites and gneisses suffered severe pressure in the upper zone of metamorphism, subsequently to the intrusion of the pegmatites.

The rocks of the Older Metamorphic Series may be said, then, to owe their present constitution and structure to three causes, of which the first is the most important. These are:—

(1.) Intense dynamo-thermal metamorphism of original quartzo-feldspathic sediments under conditions characteristic of the lower part of Grubenmann's middle zone.

(2.) Closely associated with the above and probably approximately contemporaneous with it, is a phase marked by the invasion of the series by granitic pegmatites with the development of local coarse sillimanite- or andalusite-gneiss accompanied by the dissemination of tourmaline and perhaps apatite through the whole series. These pegmatites seem to indicate the presence of a subjacent mass of granite, not as yet exposed by erosion.

(3.) At a subsequent stage, retrogressive metamorphism in the epi- or upper zone has resulted in such mineralogical changes as the alteration of biotite to chlorite and the production of occasional small quantities of epidote from a similar source. Other effects are the development of marked cataclastic structures in some of the pegmatites and the undulose extinction and rare bent cleavage laminae in the quartz and micas of many of the gneisses.

Structure and Age.—Cox (1877, p. 44), states that along the coast line north of the Jackson's Bay settlement (i.e. immediately south of the present Jackson's Bay landing) the auriferous slates appear, overlaid by mica schists, the whole striking north-east and dipping north-west at an angle of from 60° to 70°. Macfarlane (1877, p. 30) notes that the "micaceous sandstones" exposed in the gorge of the Martyr dip north-west at 35°, and that the "slates and sandstones" of the Barn Bay Range (Hope-Blue River Range) dip west at 30°. The rocks mentioned above by Macfarlane are in reality gneisses and schists of the Older Metamorphic Series, and it is quite probable that Cox's "slates" and "schists" may also belong here. The present writer observed a steep north-westerly dip in the

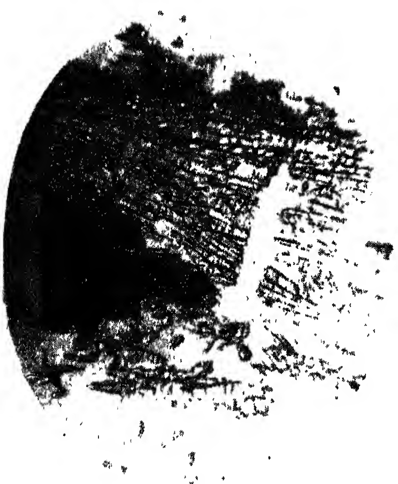

FIG. 1.

FIG. 2.

FIG. 1.—Sillimanite-gneiss from Martyr Bridge (No. 1202), showing sillimanite, biotite and clear quartz. (Polarised light). Magnification, 45 diams.

FIG. 2.—Fine gneiss one mile south of Martyr Bridge (No. 1205), showing deep brown biotite, slightly altered feldspar, clear quartz and a small crystal of apatite. (Polarised light). Magnification, 45 diams.

FIG. 3.

FIG. 4.

FIG. 3.—Banded gneiss (No. 1208b), showing large crystals of biotite with sieve-structure, and smaller grains of quartz and plates of muscovite. (Polarised light). Magnification, 45 diams.

FIG. 4.—Fine-grained gneiss from Martyr Bridge (No. 1200), showing quartz with undulose extinction, altered feldspar (speckled) a single large crystal of muscovite enclosing some quartz, and adjacent to it a small crystal of chloritised biotite. (Crossed Nicols). Magnification, 45 diams.

Fig. 5.

Fig. 6.

Fig. 5.—Banded andalusite-gneiss (No. 1211), showing brown biotite (dark) and andalusite (with high refractive index) enclosing quartz grains to give sieve-structure. (Polarised light). Magnification, 45 diams.

Fig. 6.—Knot of crystals of prismatine fringed with biotite, surrounded by clear quartz and decomposed feldspar in hornfels (No. 1214) from Cascade River Ford. (Polarised light). Magnification, 45 diams.

Fig. 7.

Fig. 8.

Fig. 7.—Biotite-quartz-muscovite-gneiss (No. 1217), Cascade Plateau. Polarised light). Magnification, 45 diams.

Fig. 8.—Pegmatite (No. 1219) from one mile south of Martyr Bridge, showing microcline, quartz and one crystal of muscovite (speckled). (Crossed Nicols.) Magnification, 45 diams.

Fig. 9.

Fig. 10.

Fig. 9.—Pegmatite (No. 1223), showing broken feldspar set in a matrix of fine crushed feldspar and quartz (Crossed Nicols). Magnification, 45 diams.

Fig. 10.—Wehrlite (No. 1225), Red Spur. Clear shattered olivine is seen passing into antigorite (clear, with low relief), while a small grey crystal of clouded augite and two black grains of chromite are also shown. (Polarised light). Magnification, 45 diams.

Fig. 11.

Fig. 12.

Fig. 11.—The same as Fig. 10, with Nicols crossed. Magnification, 45 diams.

Fig. 12.—Serpentine (No. 1244), showing typical antigorite (Crossed Nicols). Magnification, 45 diams.

Fig. 13.

Fig. 14.

Fig. 13.—(No. 1249). Talc (light) and fine antigorite (dark) replacing original enstatite. (Crossed Nicols). Magnification, 45 diams.

Fig. 14.—Albite-quartz vein (No. 1255), showing a large crystal of partially kaolinised albite set in crushed quartz and albite. (Crossed Nicols). Magnification, 45 diams.

Fig. 15.

Fig. 16.

Fig. 15.—Dioritic rock (No. 1263), showing feldspar, twinned hornblende and a micrographic intergrowth of quartz and feldspar. (Crossed Nicols). Magnification, 45 diams.

Fig. 16.—Biotite-quartz-sillimanite-gneiss (No. 1201). (Polarised light). Magnification, 45 diams.

FIG. 17.

FIG. 18.

FIG. 17.—Clear plates of antigorite, surrounded by grains and prisms of monoclinic pyroxene (high refractive index). (Polarised light). Magnification, 85 diams.

FIG. 18.—The same as Fig. 17, with Nicols crossed. Magnification, 85 diams.

FIG. 19.

FIG. 20.

FIG. 19.—Pyroxenite (No. 1261), showing pyroxene passing into antigorite. (Polarised light). Magnification, 85 diams.

FIG. 20.—The same as Fig. 19, with Nicols crossed. Magnification, 85 diams.

rocks a mile or so south of Martyr Bridge, and again in the gorge of the small stream which joins the Martyr not far below the ford. In the island in the Cascade River, a mile above its junction with the Martyr the strike is north and south and the rocks dip steeply to the west. The facts available indicate, then, that the strike of the rocks of the Older Metamorphic Series varies from north-east in the northern portion of the district mapped to north in the southern portion while the dip is always westerly, usually at high angles.

Until further field work has been done, no attempt will be made to give a definite age to the rocks of the Older Metamorphic Series, or to correlate or compare them with the schists and gneisses described by Morgan (1908) from northern Westland, or those of Fiordland described by Marshall (1907) Speight (1910) and Park (1921). It is sufficient to state that for reasons given in the next section they are believed possibly to antedate the schsits of Central Otago.

THE MANIOTOTO SERIES.

Quartz - muscovite - schists and chlorite - schists outcrop continuously west of the peridotite belt, along the crest of the Olivine Range in the area here mapped, and appear to extend along the summit of the range many miles southward. These rocks have not yet been examined in sufficient detail for a full description to be given, but they appear to be identical lithologically with the schists of Central Otago, and indeed are almost certainly continuous with these across the main dividing range. Consequently they are here grouped in the Maniototo Series of Park (e.g. 1921). These consist in the main of quartz-muscovite-schists of indubitably sedimentary origin, together with less common chlorite- or sometimes hornblende-schists probably representating original basic igneous material. They probably owe their present condition to extensive dynamic metamorphism and have the mineral composition and structures typical of Grubenmann's upper metamorphic zone (Benson 1921, p. 27). As already stated, these rocks have recently been shown to be at least pre-Permian in age, and probably extend far back into the Palaeozoic.

The only specimen collected by the writer was a soft green schist (Number 1224) from just east of the peridotite-schist junction, on the spur leading up to the Olivine Range between Woodhen Creek and the upper part of the Martyr Stream. In section the rock is seen to be typically schistose, with bands consisting chiefly of granular albite with small amounts of orthoclase and quartz, alternating with layers which consist almost entirely of epidote and chlorite. The albite is in clear usually untwinned irregularly granular crystals, the refractive index of which is always less than that of Canada Balsam, while interference figures always indicate that the crystals are biaxial and positive. The epidote is evidently rich in iron, while the chlorite is deep green, distinctly pleochroic and almost isotropic. There is a little zoisite and several large crystals of apatite in the bands rich in ferromagnesian minerals. The average grain size of the rock is from 0.1 mm. to 0.3 mm.

The relation of these schists to the rocks of the Older Metamorphic Series has not been observed, for in the area here mapped the two series are separated by the intervening belt of peridotites and serpentines. However, the great difference in metamorphic grade between the two groups, and the abundance of pegmatites in the Older Rocks and their complete absence, as far as was observed, in the schists of the Olivine Range, both suggest that the two series are distinct and it is on this assumption that the name Older Metamorphic Series has been put forward for the gneisses and schists west of the peridotite belt. It is possible, however, that these latter rocks are merely the deep-seated much more strongly metamorphised equivalent of the Maniototo schists of the Olivine Range.

The Peridotite Series.

Distribution.

Peridotites and serpentines are developed along the north-western flank of the Olivine Range from the valley of the Jackson to the southern limit of the district mapped. They form the northern end of a great mass of similar rocks, which extends for twenty miles south-west to the Red Mountain and Red Hill Range where they attain their maximum. In the area here mapped the intrusion is bounded on the north-west by the Cascade River, which marks the junction with the rocks of the Older Metamorphic Series. In the vicinity of Mt. Richards the width is about three or four miles but from this point north-eastwards it narrows off and eventually thins out and disappears completely on the north-eastern side of the Upper Jackson Valley. The trend of the peridotite belt is north-east.

Vegetation is practically absent above about 1500 ft., and in some parts the rocks descend in steep slopes of broken angular talus right down to the valley floors. This absence of vegetation, combined with the characteristic brick-red colour of the weathered rock surface, renders the peridotite belt a very striking feature in the field.

Numerous specimens were collected at frequent intervals along the crests of Red Spur, Martyr Spur and Martyr Hill, and also from the bed of the torrent which descends from Martyr Hill into the rugged and precipitous gorge of Woodhen Creek. Other specimens were obtained from the drift which builds up the Cascade Plateau, and from similar cemented drift along the track between the Martyr Ford and the saddle leading over into the Jackson Valley. This drift material represents debris brought down from the full length of the peridotite belt by the ancestral Cascade River and by the glacier which occupied its valley in Pleistocene times.

In addition, the writer has examined sections cut from about a dozen specimens which were collected some years ago by Mr. G. Moir, M.Sc., from the Red Mountain itself, some twenty miles south of the area here described, and presented by him to the Geology Department of the Otago University. The writer wishes to extend his best thanks to Mr. Moir for the trouble taken by him in collecting and carrying out specimens from this wild and remote region.

Petrography.

(1.) *Peridotites and Serpentines.*

The rocks collected *in situ* from the flanks of the Olivine Range are mainly wehrlites and dunites with less common lherzolites, nearly always partially serpentinised, usually fine-grained, and dark greenish grey in colour. Those specimens in which serpentinisation is far advanced break with the fine flaky or somewhat splintery fracture characteristic of antigorite rocks.

Though a large number of sections were examined, no trace of regular gradation in mineralogical composition or in degree of serpentinisation across the intrusive mass could be observed. Red Spur and Martyr Spur consist mainly of wehrlite, with some dunite, both of which may occasionally contain small amounts of enstatite, while dunite is developed in abundance on the southern flank of Martyr Spur where it falls away into the precipitous gorge of Woodhen Creek. Numerous dykes of pyroxenite and other rocks of a hypabyssal nature invade the main formation throughout, but these will be considered separately under (2).

Evidence of shattering is always prominent and in some places, e.g. in the gorge of Woodhen Creek, below Mt. Richards, there are zones of intense crushing and slickensiding. Chrysotile veinlets, usually about 5 mm. but sometimes reaching 20 mm. in width, are very numerous along the fracture lines throughout the whole peridotite formation.

Boulders of chromite occur in a number of places on the slopes of Martyr Spur, but no masses of any great size were seen *in situ.*

Descriptions of typical rocks are given as follows:—Number 1225 (Red Spur). The rock is an altered wehrlite which consisted originally of olivine about 75%, and diallage 25%, with minor amounts of chromite. The olivine has been much shattered and about three-quarters or more of it has been converted to colourless antigorite (Figs. 10, 11) plates and blades of which project radially inward from the cracks into central cores of still fresh olivine. In parts of the section all the olivine has thus been replaced by parallel, tufted and sometimes interwoven crystals of antigorite, but the positions of the cracks in the original olivine are still marked by fine lines of extremely minute dark particles, probably of magnetite. This latter mineral, as usually is the case in rocks of this area, is never developed in any quantity, as a result of the change from olivine to antigorite. The pyroxene occurs in rather irregular crystals from 1 mm. to 2 mm. in diameter, which sometimes enclose poikilitically smaller masses of olivine. It is always altered to a semiopaque brownish product which appears white in reflected light, though the polarisation tints of the pyroxene still show through when it is viewed between crossed nicols. Complete extinction of any one crystal cannot be obtained, but the extinction angle measured upon those small fragments of the mass which are clearest and least altered as seen under high magnification, indicates that the original pyroxene was monoclinic. Alteration of aluminous pyroxene in this way is a constant feature in the rocks of this area. Small amounts of anti-

gorite may also be developed along the cleavage cracks of the altered pyroxene, while a considerable quantity of secondary magnetite is often produced, especially round the borders of the pyroxene crystals.

Number 1226 (Red Spur). Thus is a much altered lherzolitic rock which probably consisted originally of olivine 80%, augite 10% and enstatite 10%, with a small amount of accessory chromite. The olivine shows perfectly developed mesh structure the cracks being sharply defined by a semiopaque mixture of fine talc (?) and a very little magnetite dust. The intervening grains have been replaced almost completely by blades of antigorite between which the residual remnants of olivine, though small, are clearly visible under high magnification. The aluminous pyroxene is partly clear, but in most cases has been altered to the usual almost opaque white replacing product. Orthorhombic pyroxene was not definitely determined, but there are a number of patches of coarse strongly birefringent talc with numerous grains of secondary magnetite throughout, and in view of the distinctive types of alteration constantly shown by the augite and the olivine respectively, it is thought probable that the talc-magnetite aggregates represent an iron-bearing enstatite in the original rock.

Number 1227 (Martyr Spur, half-mile below the bush line). The rock is a serpentinised dunite showing perfect mesh structure. The meshes consist of normal chrysotile serpentine spotted with strings of magnetite grains, but the enclosed cores of olivine have been converted largely to flakes of antigorite between which tiny remnants of olivine still persist.

Number 1228 (Martyr Spur, quarter-mile below the bush line). This is a partially serpentinised wehrlite very similar to Number 1225 from Red Spur.

Number 1229 (Martyr Spur, just below the bush line). Nearly 70% of the rock consists of a fine lattice of clear antigorite crystals which seem to have been derived largely from pyroxene, though probably to a minor extent also from olivine, small residuals of which occur throughout. The former mineral is mostly augite, but includes also a small proportion of enstatite, and occurs in crystals which may reach 1 mm. in length. Some of this augite has been altered to the usual brown dusty aggregate, but mostly it is in fairly clear ragged remnants and small cleavage fragments obviously in the process of being converted directly into antigorite. Secondary magnetite is fairly abundant.

Number 1230 (Martyr Spur at the bush line). In hand specimen this is a homogeneous, fine-grained, dark green serpentine with well marked flaky fracture. The section is clear and transparent and consists almost entirely of antigorite, with a little secondary magnetite and a small percentage of dusty brown opaque material representing aluminous pyroxene. In a number of places in the section there are remnants of what have been crystals of bastite showing a striking transition to antigorite into which they are now more than half converted.

Number 1231 (Martyr Spur, one quarter-mile above the bush line). This is a serpentinised dunite consisting almost entirely of altered olivine with about 5% brown opaque altered augite.

Number 1232 (Crest of Martyr Spur half-a-mile above the bush line). This is a fine-grained grey rock which in section proves to be a-half serpentinised wehrlite consisting originally of 70% olivine, 25% augite, two or three small crystals of enstatite and accessory chromite. As usual the olivine is shattered and shows perfectly the transition to antigorite, blades of which not only project radially inwards from the cracks, but also stab in every direction through all parts of the olivine grains. The crystals of monoclinic pyroxene show the usual alteration to brownish almost opaque aggregates white in reflected light, with fringing rims of dusty magnetite, but the enstatite on the other hand is unaltered except for the presence of a narrow border of fine magnetite.

Number 1233 (Martyr Hill, twenty-five yards from the eastern boundary of the peridotite mass). The rock is a wehrlite similar to the section previously described except that it is less altered. Antigorite needles are only just starting to form through the olivine, while the pyroxene, though partially altered in the usual way, is still sufficiently clear to show the extinction angle. So that it may definitely be determined as monoclinic. Strings of secondary magnetite occur along the cracks on the pyroxene and to a less extent in the olivine also. Enstatite is absent, but chromite is present in accessory amount.

Numbers 1234 and 1235 (Upper part of creek draining the southern side of Martyr Hill). The rock is a banded dunite consisting entirely of olivine and chromite, the latter being present in amounts ranging from 15% to 30% of the whole rock. In hand specimen the olivine appears fresh and clear, but high magnification beneath the microscope reveals incipient alteration to antigorite, while two or three veinlets of chrysotile occupy major cracks. The rock merges into a perfectly fresh clear dunite carrying about 2% chromite, which continues in abundance down the creek to the bottom of the gorge of Woodhen Creek. In this rock (Number 1236) needles of antigorite are very rare, though the olivine is much crushed.

The specimens collected by Mr. Moir from the vicinity of the Red Mountain include several representing the normal peridotite as well as a number of interesting dyke rocks which invade the main intrusion and will be described in the next section.

Number 1237 (western margin of Red Mountain intrusion, east of Awarua Bay). This is a greenish partially serpentinised wehrlite consisting originally of olivine (about 80%) and augite (about 20%) with some accessory magnetite. The main constituent is antigorite, through which are scattered small remnants and cleavage prisms of olivine with feathery margins where they pass into antigorite. The olivine grains show undulose extinction but lack the shattering which is such a constant feature of the rocks previously described. The pyroxene is altered to the usual brownish decomposition product. Number 1238 (Red Mountain) is a yellowish dunite which in section appears quite fresh. There is a small amount

of chromite, and in the hand specimen a single crystal of bright green chrome-diopside was observed, similar to that which is developed in some of the dykes of pyroxenite and was described by Ulrich (1890) from this area.

The Pleistocene drift which covers the whole of the Cascade Plateau consists very largely of huge boulders of peridotite which probably include material brought from along the full length of the Cascade Valley. The prevailing rock type (e.g. Numbers 1239, 1240 and 1241, from Laschelles Creek) is a fresh clear green dunite in which darker grains of pyroxene are present to the extent of about 5% or 10% so that the rock may approach to harzburgite in composition. The olivine is much crushed and has undulose extinction, but it is either quite fresh or exhibits merely the incipient stages of alteration to antigorite. The pyroxene is enstatite, usually almost clear and transparent, and sometimes shows bent cleavage lamellae. A small amount of chromite also is present. Number 1242 (from drift beside the track one quarter mile above the ford across the Martyr) is a rather similar looking rock, which on sectioning is found to contain about 15% much altered augite and about 85% olivine which in places has been converted to antigorite. This may be classed as a wehrlite.

Number 1243 (Boulder from Martyr Ford) is a fine-grained green serpentine which consists mainly of fine antigorite together with a few crystals of basite about 1 mm. in length. There is abundant secondary magnetite and a few small patches of secondary carbonate.

Number 1244 (from drift between Jackson Saddle and Martyr Bridge) is a green semitranslucent serpentine which breaks with the characteristic splintery fracture of antigorite, and resembles nephrite but for its inferior hardness (about 5 to 5½). In thin section 90% of the rock is seen to consist of fine blades of antigorite (Fig. 12) about 0.1 mm. to 0.2 mm. long, showing most perfectly the "thorn structure" of Bonney. About 5% of the rock consists of a very pale green mineral with similar structure, sometimes distinctly pleochroic with absorption $X < Z$. The crystals are elongated parallel to Z. The refractive index is slightly higher than that of antigorite, but the birefringence is distinctly greater (about 0.02) giving interference tints as high as red of the first order when the antigorite gives only greys and whites. Convergent light tests show that the mineral is biaxial and positive, with a small optic axial angle. This latter character and the higher double refraction distinguish it definitely from antigorite. The mineral appears to lie between chrysotile and xylotilite, and may be identified as an iron-bearing chrysotile or iron-poor xylotilite. Bastite also occurs in rather small amounts (about 5%) and appears in ordinary light as patches having slightly lower refractive index than the surrounding mass of antigorite crystals. The mineral shows a negative biaxial interference figure. Under high power the bastite is seen to be in the process of being converted to antigorite, needles and blades of which are forming in all directions throughout every crystal of bastite. Similar replacement of bastite has been described and figured by Benson (1914, pp. 674, 675) from serpentines in New South Wales.

(2.) *Dykes invading the Peridotites.*

Dykes and veins of pyroxenite, usually only a few inches in thickness, occur abundantly invading the peridotite mass along the whole of its extent. Similar rocks are represented among the specimens collected by Mr. Moir from Red Mountain district, and were found also as small dykes and veins traversing the dunite and wehrlite of large boulders, among the drift material of the Cascade Plateau. The abundance of these dykes probably accounts for the statement made by Ulrich (1890) who in describing the Red Mountain mass notes that "the olivine and enstatite vary much in relative proportions; while in some specimens the former greatly predominates over the latter, in others the reverse is the case." Professor Ulrich was working on specimens collected by prospectors and others; but recently obtained field evidence shows clearly that peridotites with a high olivine content constitute the main intrusive mass and that pyroxenites are minor features only.

The pyroxenites of the Olivine Range consist essentially of augite and enstatite in varying proportions, the former usually dominant, and occasionally there may be a little olivine. Many of these rocks show the effects of intense alteration which has followed along lines entirely different from those shown by the peridotites, in which conversion of olivine to antigorite, augite to a brown opaque decomposition product, and enstatite to bastite or antigorite are such constant features. Typical pyroxenites in various stages of alteration are described below:—

Number 1245 (Martyr Spur half a mile above the bush line). Dillage in subidiomorphic crystals about 2 mm. long, occasionally showing Schiller structure and always unaltered except for a slight dusting of brownish material, makes up 80% of the rock, while there are also one or two clear crystals of enstatite. The remainder consists of clear interstitial patches of antigorite, which enwrap the pyroxene and probably represent original olivine, small grains of which still remain in the surrounding mass of antigorite laths.

In Number 1246 (boulder, Cascade Plateau) over 95% of the rock is pyroxene, enstatite greatly predominating over augite, while a very little olivine and a few grains of chromite also are present. All the minerals are quite fresh. Number 1247 (Red Mountain) is also an undecomposed enstatite-rich type, which contains also about 25% of augite and a small amount of chrome-diopside. The latter mineral is brilliant emerald green in hand specimen but pale green and transparent in section. As noted by Marshall (1906, pp. 564, 565), Ulrich (1890) did not examine this latter mineral in section but identified it provisionally as enstatite. Marshall, however, definitely determined as chrome-diopside a similar mineral from the lherzolite of Cow Saddle, some twenty-five miles south of Red Mountain, and suggested that the green pyroxene from this latter locality would prove to be the same mineral.

Number 1261 (Red Mountain mass, east of Awarua Bay) is a dark green slickensided serpentine which breaks with a flaky "antigorite" fracture. The rock appears originally to have been a pyroxenite but is now more than half converted to antigorite.

Augite and enstatite are both present, but the former mineral greatly predominates over the latter. Both pyroxenes originally occurred as large crystals reaching 3 mm. in length, which are now much broken down and in many parts of the section are represented only by aggregates of small clear cleavage prisms and grains. The transition of both pyroxenes to antigorite is perfectly shown (Figs. 19, 20). Magnetite is present in accessory amounts both as a primary mineral, and also as strings thrown out along the cleavage planes of the altered pyroxene.

Number 1248 (Martyr Spur, one-third of a mile above the bush line). In hand specimen this is a greyish serpentinous rock in which small crystals of pyroxene are visible. The greater part of the rock consists of small plates of pennine with characteristic greenish grey anomolous interference tints, interspersed with less plentiful blades of antigorite and numerous small remnants of clear monoclinic pyroxene. In some parts of the section small grains (0.05 mm.) of deep red garnet are scattered in small amount through the aggregates of pennine and antigorite, usually in the vicinity of grains of magnetite. Apparently the rock consisted in the first place largely of aluminous pyroxene, which has since been altered to pennine, and a little antigorite, garnet and magnetite, through which small cleavage prisms and grains of residual pyroxene still remain in small proportions. Between these aggregates are also present smaller patches of clear felted antigorite, probably pseudomorphous after enstatite or olivine, though no trace of either mineral remains.

Number 1249 (Martyr Spur, three-quarters of a mile above the bush line). In hand specimen this is a coarse-grained rock in which abundant grey serpentinised pyroxene together with large crystals of green chlorite, bright unweathered magnetite and one crystal of reddish-brown garnet were determined. Apparently both monoclinic and orthorhombic pyroxenes were present in abundance in the unaltered rock. The former is now represented by a very fine felt of antigorite in which cleavage prisms of the original mineral still persist in one or two places in the section. The enstatite has been replaced completely by a mixture of coarse talc and finer antigorite (Fig. 13). Sometimes almost the whole of the pseudomorph consists of talc, while in other cases alternating bands of talc and fine antigorite have formed parallel to the cleavage of the original enstatite. About 5% of the rock consists of antigorite pseudomorphous after olivine. Though this mineral is completely replaced, its former presence is indicated by the characteristic curved cracks which are now defined by strings of magnetite dust. There are several very large crystals of magnetite, but neither the garnet nor the chlorite seen in the hand specimen were observed in the section.

Number 1250 (Martyr Spur, a-quarter of a mile above the bush line). The main constituent is augite (60% of the rock) the crystals of which are considerably dusted with brown decomposition products but are still definitely determinable. Pennine in clear subidiomorphic crystals about 1 mm. in diameter showing the usual greyish-green interference tint, occurs between the crystals of augite from which it seems to have been derived. Red garnet in

granular masses up to 0.2 mm. long is usually to be found associated with the pennine, but may occur in the pyroxene as well. Secondary magnetite is also fairly plentiful. In other parts of the section large crystals of augite pass into a frayed mass of small prismatic crystals of colourless diopside associated with which are small amounts of garnet, pennine and magnetite. The transition from augite to diopside is sometimes perfectly shown under high magnification. There are also several crystals, ranging up to 2 mm. in length, of a striking pale golden yellow mineral which is probably an iron-rich or titaniferous variety of olivine. There is strong pleochroism with X = golden yellow and Z = almost colourless or very faint yellow. The extinction is straight parallel to a distinct prismatic cleavage, which is the Z direction of the crystal. In several cases crystals were found to consist of three or four twinned individuals. The refractive index is fairly high and the birefringence is about equal to that of the augite. Convergent light tests indicate that the mineral is biaxial with an optic angle near 90°, so that the sign could not be determined.

Number 1251 (Red Spur). Relatively clear monoclinic pyroxene in crystals one or two millimetres long makes up 30% or 40% of the rock and passes gradually into a finely crystalline mass of pennine with greyish-green interference tints, through which residual grains and small cleavage prisms of the original pyroxene are scattered plentifully in some parts of the slide. In other parts, fine pennine has been developed in well defined bands along the cleavage cracks of the pyroxene crystals. There are also present numerous sharply bounded areas about 1 mm. to 2 mm. in length, which consist largely of granular reddish brown material much of which shows up white in reflected light. Some of this substance appears under high magnification to be translucent and is probably much altered sphene partially coated with leucoxene. Included among the grains are small amounts of pennine and serpentine.

Number 1252 (Gorge of Woodhen Creek). The specimen was collected from the great mass of crushed and slickensided green serpentinous rock which outcrops at the junction of the creek draining the south side of Martyr Hill with Woodhen Creek. Veins of chrysotile are abundant in the hand specimen. The rock appears to have consisted originally almost entirely of monoclinic pyroxene which is still present in considerable quantity. Much of the mineral has been converted to antigorite which now occurs in rounded flakes which may reach 0.5 mm. in diameter and which clearly show a definitely negative optical sign. In some crystals this alteration has taken place along the cleavage cracks of the pyroxene. Throughout most of the section, however, an unusual type of mesh structure has been developed on a very perfect scale (Figs. 17, 18). The rounded plates of antigorite referred to above are separated from one another by a meshwork built up of grains and prismatic fragments of clear transparent monoclinic pyroxene which at first sight appears from its very mode of occurrence to be secondary in origin. Careful inspection, however, reveals that this interstitial pyroxene is similar to and apparently continuous with the

undoubtedly primary pyroxene, which in other portions of the slide shows normal alteration to antigorite along the cleavage planes as already noted. It is suggested therefore that the curious mesh effect has arisen by the alteration of pyroxene to antigorite, crystals of which, in growing outward from points within the pyroxene crystals, have gradually replaced the latter mineral to a large extent, leaving borders of shattered residual pyroxene separating adjacent plates and masses of antigorite from one another. A further complication has been introduced by subsequent shearing and shattering of the whole rock, after which microscopic veins of chrysotile have been formed along the cracks so produced. In some parts chrysotile appears to have replaced completely the previously formed antigorite so that there are large patches of normal chrysotile serpentine enclosing grains of residual pyroxene, which lie adjacent to the aggregates of antigorite and pyroxene just described. Pressure effects are seen in the universal undulose extinction of the antigorite and in pronounced bending of some of the veins of chrysotile.

Number 1253 (Boulder, Martyr Ford). The rock is a green serpentine which seems originally to have consisted almost entirely of clear transparent monoclinic pyroxene, half of which is now converted to chrysotile serpentine. The transition is perfectly shown. In some parts of the section there is a tendency for the serpentine to show rough antigorite structure, and it is possible that this mineral has been developed in small amount from the chrysotile as a result of pressure. A single large crystal of bastite was noted, while there are also several veinlets of talc running through the mesh of chrysotile. A small amount of secondary magnetite is present in some parts of the section.

Although recorded by Ulrich (1890) from the Red Mountain area, dykes of normal gabbro-pegmatite were not found at all in the district described in the present paper. Dykes of light-coloured rocks were occasionally met with, however, and microscopic examination shows that these vary considerably in composition.

Number 1254 (Martyr Spur). The specimen was obtained from a dyke of hard white rock several feet in width, which cuts the peridotite mass and outcrops on the crest of Martyr Spur just where the heavy bush gives way to subalpine scrub. The rock is much altered, and under low magnification appears to consist largely of semiopaque white material interspersed with clear irregular patches of finely felted antigorite which constitute 15% of the section. There are also one or two large crystals of unaltered diopside the margins of which feather out into the antigorite. Under high power, the white almost opaque mass is seen to consist largely of colourless grossularite in very small clear grains, intimately associated with which are slender prisms of secondary pyroxene and laths of antigorite. Most of this pyroxene is enstatite, but diopside is also present. There is a small quantity of secondary magnetite and also what appear to be residual altered grains of original pyroxene in some parts of the section. The rock is clearly allied to the garnet-pyroxene rocks of the peridotite belt of Nelson, to which Marshall (1911) gave the name, rodingite. Benson (1918, p. 686)

noted very similar rocks in the Great Serpentine Belt of New South Wales. One of these he describes as consisting entirely of garnet containing lakelets of antigorite which represent original pyroxene, and he notes at the same time that the garnet has encroached considerably upon the pyroxene boundary. In a recent paper Grange (1927, pp. 162-163) mentions the frequent presence of diopside, zoisite and prehnite in the Nelson rocks, but apparently secondary enstatite, though so abundant in the rock just described, is absent both from the rodingites of Nelson and the similar garnetiferous rocks from New South Wales.

Number 1255. The specimen was obtained from a narrow dyke of hard even-grained white rock which cuts the peridotite mass about half-way down the gorge of the creek flowing from the southern slopes of Martyr Hill into Woodhen Creek. The rock consists almost entirely of albite and quartz in equal proportions. The albite occurs in tabular crystals about 3 mm. in length, and is much crushed and shattered into smaller angular fragments in many parts of the slide. Much of it is untwinned, though albite twins were seen in several instances, but the low refractive index and definitely positive optical character in every case allow the mineral to be determined with certainty. The large crystals of albite are set in a matrix (Fig. 14) which consists almost entirely of much crushed quartz in irregular grains ranging from 0.05 mm. to 0.5 mm., which show undulose extinction between crossed nicols. Epidote occurs in strings of small grains along the junctions between the large feldspars and the surrounding mass of quartz grains, and in several places is developed as veinlets along cracks. Benson (1918, p. 691) has described similar rocks from dykes cutting the peridotite of the Great Serpentine Belt of New South Wales. The writer has been fortunate enough to have had the opportunity of examining Professor Benson's sections, one of which (M.B. 230) is almost identical with the rock just described.

Number 1256 (Boulder, Martyr Ford). In hand specimen the rock is white with ill-defined bands of a light brownish tint. In section the most conspicuous mineral is tremolite, which occurs in clear prismatic crystals (0.5 mm. $\times$ 0.1 mm.) and ragged torn flakes of similar size, which are set in a very fine crushed matrix consisting of tremolite, antigorite and a small amount of a clear mineral with refractive index less than that of Canada Balsam—probably albite. The prisms of tremolite frequently show simple twinning. There are also a few small crystals of augite and several grains of magnetite in the process of being converted to limonite. The rock probably represents an extremely crushed and altered gabbroid dyke-rock originally very rich in pyroxene.

Number 1257 (Boulder, Martyr Ford). In hand specimen this is a whitish or light grey homogeneous fine-grained rock with a flaky fracture. Under low magnification, the section is seen to consist for the most part of a finely granular almost opaque white matrix through which are streaked irregularly drawn out patches of clear transparent material which make up about one-fifth of the rock. Under high power the white semiopaque matrix appears

to be made up almost entirely of granular pleochroic yellowish-green epidote, intermixed with much less abundant, fine, transparent grains which are probably albite and quartz. One or two tiny crystals of brown hornblende and a little zoisite were also noted. The clear lenses and streaks consist mainly of albite or oligoclase-albite intermixed with smaller amounts of finely granular quartz. The albite is water-clear and sometimes shows polysynthetic twinning. In one or two cases crystals ranging up to 1 mm. in length were observed, but usually the mineral is in small interlocking grains. In hand specimen the rock closely resembles specimens of "white gabbro" or gabbro-granulite collected by Professor W. N. Benson from Carrick Luz in the Lizard district of Cornwall, and described by Flett and Hill (1912, pp. 87-90). In these, however, the pyroxene is granulated and often converted wholly or partially to amphibole while the feldspar either goes over to saussurite or is simply crushed; but in Number 1257 described above there has been interaction between the augite and plagioclase, which have ultimately been altered to epidote, albite and a little quartz—a reaction involving loss of magnesium.

Number 1258. The specimen was collected by Mr. Moir from a dyke in the peridotite near the summit of Red Mountain. About half the rock consists of large idiomorphic crystals of hornblende (about 1.5 mm. × 1 mm.), yellowish to brownish green in colour, which sometimes is simply twinned. These are set in a fine granular mass the main constitutent of which is zoisite showing strong Prussian blue interference tints, together with minor quantities of albite and quartz. Sometimes the interstitial albite is in crystalline continuity throughout patches as much as .25 mm. in diameter, the twinning lamellae also being continuous across this distance. There is a small amount of rather indefinite chlorite, while a single crystal of tremolite, bordered with brown hornblende, was observed. The rock probably represents a gabbroid dyke, in which the augite has been converted to hornblende and the labradorite to zoisite and albite. Recrystallisation must, however, have been very complete since the hornblende now shows no trace of secondary origin.

Number 1259 (Dyke, Red Mountain). This also is a much altered dyke rock consisting mainly of hornblende and altered feldspar in equal proportions. The hornblende is in large ragged prismatic crystals, often showing bent cleavage lamellae, and a curious pinkish brown in colour. The pleochroism is strong (absorption $Z > Y > X$), the extinction angle is 18°, the elongation is positive and the opticial sign negative. In parts of the section the hornblende passes into tufted groups of slender prisms of tremolite. The feldspar is intensely altered to an almost opaque white aggregate which appears to be largely zoisite and quartz. Secondary epidote and clear quartz occur in small veinlets occupying cracks.

Number 1260 (Vein in peridotite, Red Mountain). This is an interesting rock which in hand specimen is very hard, finely granular, irregularly streaked and pinkish in colour. It consists

almost entirely of clear unaltered monoclinic pyroxene (probably diopside) in crystals ranging up to 2 mm. and a slightly less amount of pale pink faintly pleochroic vesuvianite. The latter mineral may easily be distinguished by its colour, high refractive index, very low double refraction giving an anomolous greyish green interference tint, distinct prismatic cleavage parallel to which there is straight extinction, uniaxial negative interference figure and negative elongation parallel to the vertical axis. In some cases it has formed as borders round crystals of diopside, while in others it appears to be enclosed by that mineral. Veinlets of zoisite 0.2 mm. wide cut the section sharply in one place. In another section (Number 1260a) of the same rock, streaks consisting almost entirely of aggregated prisms and grains of diopside were noted, while about 1% of the rock consists of green pennine scattered in small patches throughout the main mass of pyroxene and vesuvianite. Grange (1927, p. 163) mentions the occurrence of vesuvianite in the fine-grained "rodingites" of Nelson, and calls attention to the presence of grossularite, diopside and vesuvianite in veins described by Graham (1917) from the serpentines of Quebec.

Discussion of Alteration Phenomena.

The peridotites, pyroxenites and other rocks of the ultrabasic intrusive series nearly all exhibit in greater or less degree the effects of various types of alteration which seem to have followed closely upon the intrusion of the mass, apparently largely as the result of hydrothermal processes. Partial serpentinisation is undoubtedly the most widely developed of these changes in the main peridotite mass. Usually olivine, enstatite and less commonly monoclinic pyroxene show a direct transition to antigorite, while most of the aluminous pyroxene has become coated with a cloudy brownish or white decomposition product which sometimes renders the mineral almost opaque. This latter phenomenon has been noted by Bartrum and Turner (1929) in the peridotites of the North Cape area. Occasionally bastite has first been formed from enstatite, and chrysotile from olivine, while at a later stage both bastite and chrysotile show partial or complete replacement by antigorite much as described by Benson (1914, pp. 674, 675) from New South Wales serpentines. When this transformation is complete, the original parallel structure of the bastite and mesh structure of the chrysotile are indicated only by strings of magnetite dust seen in ordinary polarised light, while between crossed nicols the whole mass shows up as a uniform aggregate of antigorite, with perfectly developed "thorn" structure.

This universal abundance of antigorite and absence of chrysotile other than in veinlets of more recent development, is conclusive evidence, according to Harker (1919, p 87), that the process of serpentinisation took place under considerable shearing stress. This conclusion is amply supported by the invariable shattering of peridotites and serpentines alike and by frequently observed undulose extinction in crystals of olivine, pyroxene and antigorite.

The hypabyssal rocks which invade the main peridotite mass show in many cases mineral transformations which are considerably

more diverse, but are still indicative of accompanying pressure and shearing stress. Olivine, if present, is always altered partially or wholly to antigorite. The enstatite is usually altered to the same mineral just as in the normal peridotites, but sometimes it has been replaced by talc, a mixture of talc and antigorite, or rarely by bastite. The augite is frequently converted into pennine, with which grains of garnet or prisms of diopside may be associated. Sometimes it is altered to antigorite or to tremolite with subordinate antigorite, while rarely it may be decomposed to the opaque brownish substance which is so commonly met with in the wehrlites of the main intrusion. In one case the conversion of augite to diopside was observed.

In some specimens representing very much sheared and altered gabbroid rocks, there has been fairly complete reaction between the original constituent minerals with the production of a new association in which stress minerals are often predominant. In this way hornblende-zoisite rocks such as Numbers 1258 and 1259, epidote-albite rocks such as Number 1257 and one rock (Number 1256) consisting almost entirely of tremolite with subordinate antigorite and a little albite, have been produced.

In yet other cases, rocks containing in quantity one of the heavy lime-aluminium silicates grossularite and vesuvianite have been formed. Doubtless the grossularite has originated in a similar way to that of the "rodingites" and related rocks of Nelson in which according to Benson (1926, p. 43) it is a secondary mineral which has been formed under the influence of concentrated magmatic water. Grange (1927, p. 160) expresses a similar idea in these words: ". . . . the rocks containing diallage are really altered gabbros, the prehnite and grossularite being secondary after feldspar. The dense white rocks consist of grossularite and diopside and are probably veins formed by solutions which have taken lime, magnesia, and a little alumina from the pyroxene." In the present case (Number 1254) the rock now consists largely of grossularite, enstatite and antigorite, which have been formed probably by the alteration, by magmatic water under pressure, of a rock consisting originally of diallage and some basic plagioclase. The change involved may perhaps be expressed by the following equation in which the variable alumina of the diallage has been neglected.

$$\underset{\text{(Anorthite)}}{Ca\,Al_2\,Si_2\,O_8} + \underset{\text{(Diallage)}}{2Ca\,Mg\,(Si\,O_3)_2}$$

$$= \underset{\text{(Grossularite)}}{Ca_3\,Al_2\,(Si\,O_4)} + \underset{\text{(Enstatite)}}{2Mg\,Si\,O_3} + Si\,O_2$$

Since the whole transformation is brought about in the presence of water, the production of antigorite in addition to enstatite, and the removal of the extra molecule of silica and of any albite derived from the plagioclase is readily explained.

Graham (1917, pp. 174 - 177) has described grossularite-vesuvianite- and diopside-bearing veins from the serpentines of Quebec, and considers that they originated from the residue of a granitic magma, rich in silica and volatile constituents, which

became enriched in lime and alumina dissolved from the pyroxene of the invaded peridotites and pyroxenites. It seems probable, in the absence of any such invading granites from the present peridotite mass, that the vesuvianite-diopside veins of Red Mountain (Numbers 1260, 1260a) have originated in a similar way to the grossularite-enstatite rock of Martyr Spur, from the reassortment of molecules already present in pyroxene-rich gabbros and peridotites, without any addition of material, other than water, from external sources.

Tectonic Conditions and Date of Intrusion.

Professor Park in his report of 1887 suggested that the peridotites of Red Mountain had risen up along a great fault plane separating the Maniototo Schists of Central Otago on the east from rocks on the west which were identified by him as the Te Anau Series. In the present area two strong lines of evidence also lead to the conclusion that the intrusion has been effected along a major fault line. In the first place the middle part of the Cascade Valley which marks the north-western margin of the intrusive mass, has a definitely north-east trend which is continued, across a very low saddle, in the valley of the Jackson, which follows this direction for about ten miles to its junction with the Arawata River. The general trend of the whole peridotite belt is also north-east and accords well with the north-easterly fault lines developed throughout Westland. In the second place the rocks on the landward side of the intrusion are the quartz-muscovite-schists of the Maniototo Series, while those on the seaward side are the strongly metamorphosed gneisses of the Older Metamorphic Series. The regular perpendicular junction of the peridotite mass and the schists of the Olivine Range, as displayed in the valleys of Martyr and Woodhen Creeks, also support this conclusion. The rocks on either side of the Jackson Valley have not yet been examined and compared.

The age of the peridotites of the Cascade Valley–Red Mountain belt is not definitely known, except for the fact that they must certainly post-date the schists of the Maniototo Series. It is probable, however, that they may be correlated more or less closely with the other peridotites of the South Island, i.e. with the intrusions of Nelson, Hokitika district, Cow Saddle (Western Otago) and Milford Sound. Most recent workers believe that these invaded the overlying strata in Early Cretaceous times during the great post-Hokonui folding movement.

It seems then that the peridotite mass rose up along a plane of shearing at an early stage in this orogeny, and that the subsequent partial serpentinisation and other mineralogical transformations took place immediately after, under conditions of considerable stress, during the later stages of folding. This view is in accordance with the generalisations advanced by Benson (1926) on the tectonic conditions accompanying the intrusion of ultrabasic rocks.

The Dioritic Rocks.

Dioritic rocks of unknown age are represented fairly abundantly among the boulders in Laschelles Creek and in the small creek draining into Martyr Creek just below the ford across the latter stream. Number 1262 from the former locality and Number 1263 from the latter are closely similar rocks consisting essentially of equal quantities of hornblende and feldspar. The hornblende is brown, strongly pleochroic, sometimes simply twinned, and occurs in idiomorphic crystals 3 mm. long by 1 mm. wide. It is sometimes slightly altered to chlorite. The feldspar is so decomposed that it is impossible in most cases to determine what variety is present, except that in Number 1262 a small proportion of it appears to have been orthoclase. Quartz is present to the extent of 5% to 10%, intergrown in perfect micropegmatitic fashion with the feldspar (Fig. 15), as well as in isolated grains. Coarse apatite in slender prisms ranging up to 2 mm. in length is very abundant while pyrite and magnetite are both plentiful, the former showing alteration to haematite. The rocks may be classed as micropegmatitic quartz-hornblende-porphyrites.

Number 1264 is a very coarse diorite-pegmatite from boulders in the Cascade River just below its junction with the Martyr. Hornblende in pale green idiomorphic prisms 3 mm. to 4 cms. in length makes up to 40% of the rock, while the remainder consists of white very altered feldspar which is sometimes recognisable as andesine. Very coarse apatite prisms are sparsely present.

Pleistocene and Recent Accumulations.*

Pleistocene conglomerates and drift material outcrop over wide areas in the vicinity of the Lower Cascade Valley, especially over the great uplifted area known as the Cascade Plateau, while the Cascade River is itself bordered by wide flats of Recent alluvium and swamp accumulations along the last ten miles of its course. The origin of the Cascade Plateau and other curious physiographic features of the area will be discussed in a later paper when further field work has been carried out.

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*Recent field work shows that much of the detrital material underlying the Cascade Plateau is probably Late Pliocene, though the surface is for the most part mantled with Pleistocene moraines.

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Yolk-sac Dropsy in Newly Hatched Trout.

By R. R. D. Milligan.

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This paper is a record of observations made in the hatcheries of the North Canterbury Acclimatisation Society at Christchurch, New Zealand, during the hatching seasons of 1928 and 1929. The Society kindly granted facilities for this study, and the author here wishes to record his thanks. Thanks are also due to the curator (Mr. D. Hope) for his most courteous assistance in many tedious observations. For the most part *S. fario* was used, and conclusions are meant to refer to *S. fario* in particular, although our experience in regard to this condition is that both *S. irideus* and *S. salar* differ in no fundamental respect.

Normal Development.

Newly-hatched trout absorb both yolk and the surrounding membranes or sac in about eight weeks from the time of fertilization, or 38 days from the time of eyeing, and 21 days from the time of leaving the egg. When the yolk is absorbed the fish rise to the surface and begin to feed. Until then they are entirely dependent on the food materials in the yolk together with water, salts and oxygen from the environment. The water in the hatching boxes in the Christchurch hatchery is aerated by falls between the upper and lower tiers of boxes and by an open race and fall from the artesian well-source to the upper tier. The temperature is maintained at a remarkably constant level, namely 54°F, during the whole period of hatching. In this paper, the term *alevin* means trout which have not yet absorbed the yolk, and the term *fry* will imply that the yolk has been completely absorbed.

Yolk-sac Dropsy.

Absorption of yolk and the surrounding membranes or sac, fails to occur in some of the fish, and this condition is variously known as *blue-swelling, blue-sac, hydrocele embryonale,* and *yolk-sac dropsy.* The latter term will be used in this paper. In this disease, the space between the inner and outer membranous coverings of the yolk becomes filled with opalescent fluid which gradually increases in amount until the bulk of the fluid-holding sac or *hydrocele* becomes as great as or even much greater than the yolk itself. Towards the fatal termination of the disease it is obvious that the yolk has not been absorbed as rapidly as in normal fish, but in the earlier stages this failure of absorption is not a prominent feature. Sooner or later, all the alevins which have any considerable degree of swelling die, but whether because of the mechanical disability of the dropsy, or for some reason of toxicity, is not known. The opinion of most hatchery

curators in New Zealand is that all the fish which contract the disease die in the alevin stage, but our experience is that only a small proportion of affected fish develop the hugely swollen sac, and only these latter fail to reach the fry stage. The largest death-rate that author has seen is no more than one per cent. of the total hatching. Several curators, however, say that in some seasons as many as thirty or forty per cent. will die of the disease. Yolk-sac dropsy is apparently well-known in other parts of the world, but as to its percentage incidence elsewhere no information has been available to the author. The only printed account of the disease at hand is contained in the text-book "Handbuch der Fischkrankheiten," by Dr. Bruno Hofer. The substance of Hofer's account is as follows:—

> The disease appears sporadically; the first symptom being an enlarged sac, which, after a time, becomes so heavy that the fish are unable to rise to the surface. After a few days the sac usually bursts, resulting in the death of the fish in the first week after hatching. Many think that the disease is due to shock or pressure in the ova at stripping. The use of female fish that are too young is also held to be a cause, but without evidence. Von Betegh made a study of the disease and concluded that it is due to infection by a specific organism. He isolated a diplo-bacillus in pure culture in the contents of the sac and proposed to name it *diplo-bacillus liquefaciens piscium.*

In some respects Hofer's very brief account differs from our experience at Christchurch. We do not see marked cases in the first week. The second week is the time when the disease becomes noticeable, but the development of large sacs is only gradual. The author does not know whether the sacs are heavier than the rest of the fish or lighter, but any change in density would probably be in the latter direction, unless salts had been absorbed from the hatching water. It is not common to see diseased alevins burst. Although the author has seen thousands of cases he has not seen this. Again, our experience is that the fish appear to be surprisingly little distressed by the burden of their sacs. They move freely on the bottom with their normal companions, even in the more turbulent head waters of the hatching boxes, and this vitality is retained until the last few days. Comparative counts of the incidence of the disease in top-half and bottom-half of the race gave practically identical percentages. That they should be able to live for several weeks with this bulky impediment to movement suggests that the disease is not an intensely toxic process and that death is in the end due to a slowly progressing impairment of vital organs. When one pricks the sac with a needle the fluid escapes under pressure, but all the cases so treated by the author have died within one to three days.

Suggested Causes.

When little of fundamental importance is known about a disease the alleged causes and cures are correspondingly numerous. In New Zealand, overcrowding, deficiency of earth, lack of aeration, poor quality of parent fish, injury in stripping, irritative action of radium emanation, have all been regarded as causes by various observers.

That the disease is due to some abnormality in parental material or environment or both together, is obvious enough, but it is as yet impossible to say which will finally be blamed. Parental material will be cleared of suspicion only when all ova, from whatever source, can be induced to show the disease in response to known and deliberate alterations of the environment; and environmental causes will be discounted when all or some of the ova of certain fish show the disease no matter what variations of hatching water they are subjected to. But it may turn out that water itself unable to produce the disease in all ova is provocative only when presented with a certain kind of fertilised egg. A problem of this sort with so many possibilities which could only be eliminated, each in turn, by the most patient and laborious procedure would be most difficult of solution unless conspicuous features present attractive paths of exploration. It is the author's opinion that such clues are not likely to appear until statistical observation of the incidence of the disease is more thorough than hitherto.

Overcrowding.

This does not seem a likely cause in the Christchurch hatchery since, although derived from a poorly oxygenated artesian source, special means are taken to add air to the water. But overcrowding as a cause might mean something different from lack of oxygen. It might mean, for example, that waste products accumulate in the neighbourhood of the ova or fish, or that non-gaseous materials in the environment normally taken in by the fish are reduced by overcrowding to ineffective concentrations. When experimental overcrowding fails to produce a conspicuous crop of dropsies this line of investigation appears sterile. In the local hatchery one finds no evidence pointing to overcrowding as a cause, although a direct negative will not be possible until it is shown that no ingredient in the environment is tending to run short and no accumulation of waste products occurs. The water here is fairly well buffered, and by colorimetric methods the author could find no alteration in hydrogenion concentration when the entering flow and samples that had passed over 32,000 ova alevins were compared. This, of course, is due to the large volume of water flowing down the boxes, since the fish are actively respiring and adding carbon dioxide to the water, but in amounts too minute to estimate in these conditions. Alevins, however, are wont to collect together in large swarm masses, and it is conceivable that some of the innermost fish are subjected to unfavourable conditions sufficient to account for the cases of dropsy. When we placed, in the 1928 season, three-quarters of the usual number in one half-box and one-quarter in the other, the counts of marked cases of the disease turned out to be practically identical, namely, 1.3 per cent. for the former, and 1.4 per cent. for the latter. This, however, is not a clear proof, since the scattering of the fish was much the same in both boxes and the smaller number of fish appeared to make as dense a swarm mass (but less spread out) as the larger number. Probably a better way would be either to divide a box into many sub-divisions, or to try the effect of a number of pebbles as isolated swarm centres. The tentative conclusion of this observation, however, is that the ordinary percentage

of yolk-sac dropsy is not attributable to overcrowding in the conventional sense. This leaves open the question whether an enormous overcrowding would produce exceptional percentages of the disease; but as will be seen later, the exceptional percentages (thirty or forty) actually found by some curators were not accompanied by exceptional overcrowding.

Lack of Aeration.

This aspect cannot be separated from the question of overcrowding, since it is part of the presumed inner meaning of the term. A number of New Zealand curators think that yolk-sac dropsy is due to deficient aeration, but no systematic estimations of the oxygen and carbon dioxide content of the local hatching water has been done except by Farr (1) and Farr and Florance (2) on the hatchery water in Christchurch about twenty years ago.* At that time the boxes were arranged and stocked differently from now, although the artesian source is the same in both cases. Quoting these figures a comparison of the top box with the bottom shows:—

TOP BOX. C.C. per Litre		BOTTOM BOX. C.C. per Litre.	DIFFERENCE.
Nitrogen, Argon } etc.	16.82	15.98	0.84
Oxygen	5.34	5.68	0.34
Carbon Dioxide	1.80	1.88	0.08
Temperature	12.7°C		

While it may be doubted whether the increase in carbon dioxide was detectable by the methods used, it is clear that rippling and falling from box to box removed an appreciable quantity of nitrogen and added oxygen at the same time.

The River Avon at Christchurch gave the following figures:—

Nitrogen, Argon } etc.	15.36 C.C. per Litre.
Oxygen	7.74 " " "
Carbon Dioxide	1.30 " " "
Temperature	11.4°C.

These figures are just about the ordinary saturation values at N.T.P.

*Since the above was written, the Department of Internal Affairs have supplied me with the following figures for the Tongariro Hatchery:—

p H value	6.8		
	Per Litre.		Parts per 100,000
Dissolved CO_2	4.48 cc.	Total Solids	12.9
Dissolved Oxygen	6.54 cc.	Volatile & Organic Matter	2.3
		Chlorine as Chlorides	0.82

In this hatchery, the death rate from dropsy is no more than 0.2%. Only Rainbow trout are hatched.

Taking the Avon figures as 100, the gas content of the two boxes is represented as follows:—

TOP BOX.		BOTTOM BOX.
Nitrogen, Argon } etc.	109.5	104.0
Oxygen	69.0	73.4
Carbon Dioxide	138.5	144.6

Note that carbon dioxide includes all the gas given off by boiling, i.e., both free and that combined with base are included.

The fact that special procedures are necessary to aerate artesian water to its full capacity suggests that deficiency of oxygen might cause yolk-sac dropsy. It should be noted, however, that the quantity of oxygen present is enormously more than could be used up by the developing eggs or alevins, and it will be seen that the water in the lowermost tier of five boxes increases its holding of the gas in spite of the fact that it flowed over many thousands of fish. To hypothecate an unfavourable effect one would have to assume that a solution pressure of oxygen equal to about 70 per cent. of the maximum provides too small a gradient for adequate interchange at the lung surface. There are various general grounds for rejecting this assumption, and in particular the fact that the majority of the fish do not contract the disease; and even if the assumption were true it would be true only for certain ova and alevins and not for others. In 1929 the author aerated a box of *S. fario* by special means but the results did not favour the idea that deficiency of oxygen was here a cause of the disease.

Counts of severe cases only:—

Specially aerated Box	1.2 per cent.
Non-aerated Box	1.0 per cent.

This experiment was done on pond fish, whose ova, according to some observers, are said to be particularly liable to give a high incidence of yolk-sac dropsy. As a final comment, it may be added that yolk-sac dropsy is not limited in New Zealand to poorly-aerated artesian water but occurs in all, or practically all, of our hatcheries, although most of them are supplied from small and presumably well aerated streams.

Radium.

It will be noticed in the gas analyses just given that Farr and Florance found that nitrogen and argon are present in the Christchurch artesian water in greater amount than in river water. With these inert gases is associated a considerable quantity of radium (1 and 2), and, like them, the emanation is decreased in amount by falls and ripples. In a series of five hatching boxes at the hatchery the quantity dropped from 126 arbitrary units at the top to 69 units at the bottom. It was also found by Farr and Florance that death in

the ova stage and yolk-sac dropsy in the alevin stage were proportionately reduced as shown for the latter in this table:—

BOX NO.	PERCENTAGE OF FISH DEVELOPING BLUE-SWELLING.	RADIUM EMANATION.
1	19.5	126
2	13.0	111
3	15.4	95
4	13.0	83
5	13.0	69

For death of ova the decreases were much more nearly parallel.

Farr and Florance, therefore, were of the opinion that radium emanation might be the destructive agent, but in 1909 they had no supply of radium which would permit them to add emanation to the hatching boxes to test out the theory. It will be noticed that their percentages of dropsy are much higher than the author has so far recorded. Presumably Farr and Florance counted all degrees of the condition. As is later shown in this paper the percentage incidence varies at different times, so that it was found desirable to compare only those which were so badly affected that they were almost certain to die of the disease. Since 7,500 ova went to the boxes used by Farr and Florance it is possible that the alevins were not all of the same age. The figure 13% is noticeable, as it occurs in the second box, although the quantity of emanation is relatively little reduced. In 1928 the author obtained a supply of emanation from the radon plant at Wellington Hospital for the purpose of testing out the theory of emanation as a cause of dropsy. The supply was obtained fresh each week and capillary tubes bearing the gas were broken each day deep in a twenty litre vessel of water which delivered by continuous drip into the head of a hatching box during the whole time of hatching and development right up to the fry stage. By a siphon attachment the emanation container was kept full of water so that no loss occurred except that due to decay of radio-activity. The emanation in a control trough was estimated by a gold leaf electroscope as 1.5 $\times$ 10–12 Curie; whereas in the trough into which emanation was delivered there was always from one hundred to one hundred and fifty times this amount. In spite of this great increase as compared with normal troughs, the death rate in the egg stage was unaltered and the percentage of alevins suffering from yolk-sac dropsy was practically identical, namely:—

(1) Ordinary hatching boxes .... 0.96 per cent.
(2) With emanation added .... 0.92 per cent.

It seems conclusive that emanation cannot be an ordinary cause of yolk-sac dropsy. This is the result one would expect when it is recalled that most of New Zealand hatcheries are supplied from small open streams where emanation could not be in such concentrations as occur in Christchurch but where dropsy is just as prevalent as with us.

Earth and Iodine.

For twelve or thirteen years the local curator (Mr. D. Hope) has added a slush of garden earth to the hatching boxes each morning, from the time the ova hatch right up to the rising of the fry. Before he commenced to do this great losses due to dropsy were occurring, amounting sometimes to thirty per cent. or more. While he was in charge of the Mataura hatchery, prior to coming to Christchurch, the boxes there were often silted over by a fresh in the river and sometimes the ova were quite buried by the silt. Thinking this might prevent dropsy he tried the effect of adding earth to the Christchurch water and was delighted to find that he was never again troubled by the disease to the former extent. The death rate since then has never been more than about one per cent. He found that rich garden loam was the most effective, while sandy soil was ineffective, and light soils gave an intermediate result. This was in the old hatchery where the boxes were smaller and the ova more crowded than now. In 1928 the author proposed to investigate this medicative practice but an expected supply of ova not coming to hand the experiment was not fully controlled. A weak solution of iodine was, however, added to one box during the whole hatching period and counts showed that the iodised water had practically the same number of diseased fish as a box to which earth had been added. This raised our hopes that a clue to the origin of the disease had been found. The reason for trying potassium iodide was that endemic goitre is very prevalent in Christchurch and with it is associated a relative deficiency of iodine in the soil and water of the district. In the Acclimatisation Society's ponds about one per cent. of the three-year-old trout contract goitre, and our idea was that yolk-sac dropsy might also be a deficiency disease due to lack of iodine. Analyses of soil for iodine content made by the author was found to have an average content of 0.022 mgm. of iodine per 100 gm., dry weight, while sandy soil as used had none or a faint trace only. In 1929 the effect of soil and iodine was again investigated, but this time with adequate controls. The iodine was added by continuous drip into the top of a race using the same arrangement as had been used for emanation. The solution was a 0.5 per cent. potassium iodide and the administration was maintained from the time of arrival of the ova until the fry rose to the surface—eight weeks in all. Estimation of iodine gave the following results:—

(1) Normal ova—6.0×10^{-7}gm. (dry).
(2) Normal alevins—2.5×10^{-7}gm. (dry).
(3) Normal trough water—2.3×10^{-9}gm.

It appears from this that the ova are surrounded by water containing only about one thousandth as much iodine and that during the process of hatching some iodine is lost, although the difference here recorded seems excessive and merits repetition. In iodised water the following results were obtained:—

(1) Iodised water—2.4×10^{-6}.
(2) Iodised ova—3.0×10^{-7} (dry).
(3) Iodised alevin—4.8×10^{-6} (dry).

So that in spite of the water containing about one thousand times as much iodine as uniodised water the ova did not gain iodine

but apparently lost a little. The alevins, however, were able to take in and hold eight times as much iodine as uniodised fish, but this extra content made no difference to the incidence of yolk-sac dropsy, as the following counts show:—

(1) Iodised box .... 1.9 per cent. (severe cases only)
(2) With earth but no iodine 3.1 per cent. (severe cases only)
(3) Neither earth nor iodine 1.3 per cent. (severe cases only)

It will be noticed that the counts vary unexpectedly, but this is probably due to the stage of the disease in the particular box. The ova are added to the boxes as they arrive from the stripping pen and each box holds alevins of different hatching age. That the counts vary with this age is shown by the figures for the same boxes four days later:—

(1) Iodised box .... 0.9 per cent. (severe cases only)
(2) With earth but no iodine 1.4 per cent. (severe cases only)
(3) Neither earth nor iodine 0.7 per cent. (severe cases only)

Since few fish had died in these boxes it appeared that half of the alevins had recovered. This recovery was well illustrated in several boxes, of which the following is typical:—

(1) Second week after hatching—23 per cent. (mild cases)
(2) Fourth week after hatching—0.8 per cent. (severe cases)

While it is possible that a more meticulous examination would show even greater percentages, in general one found nearly thirty per cent. of mild cases in the early days, while at the end almost the only fish in which abnormality could be detected were the severe cases which would undoubtedly die of the disease. Counting mild cases is a most fatiguing task, and one has to look intently to determine which show or do not show excess of fluid in the yolk-sac, but the percentage in which abnormality is detectable steadily diminishes as the fish approach the fry stage.

To count the severe cases, weighing the fish in hauls was adopted, instead of directly counting the whole population. The conclusion is clear: that deficiency of iodine plays no part in the ordinary causation of the disease. As to the iodine-holding powers of ova and alevin, it is a point of interest to consider how the iodine might get into the body of the fish. At this stage they are still dependent on the yolk and have not yet taken food in by the gullet. It appears possible, however, that they might make swallowing movements from time to time and so ingest both water and salts. Although the author has watched for this he has not yet seen it occur. Towards the latter stages, when they are near to rising, it is probable that they try experimental swallowing movements before the reflex chain which is soon to be used in snapping at food has been perfectly established as a going concern. On the other hand, it would not seem impossible for the gill to absorb water and salts at the same time as dissolved gases. Sumner (3) describes experiments in which carp lost or gained weight according as the gill was supplied with salty or non-salty water. A further possible port of entry is the skin, which may be more pervious in these stages than later on. It should be noted that normal alevins hold about 500 times as much iodine as ordinary

trough water, while iodised alevins have about ten times as much iodine as the iodised water of this experiment. This means that either the ingestive organ must specially select iodine and not water and dissolved salts as a whole, or else the excretory organs have to do work to maintain the iodine concentration of the internal environment at such a low level as compared with the hatching water. The ingestive organ, may, of course, be the thyroid gland itself, which in the trout is below the floor of the mouth and closely associated with the gill. It may be of interest to quote here my estimations of iodine in the goitres of *S. fario* pond fish as no record of this having been done is known to the author. The iodine of eight goitres averaged out as 2.8×10^{-5} (dry weight), which is approximately 160 times as much as was held by the whole body of normal alevins. These third-year trout weighed on the average three thousand times as much as each alevin. Even allowing that iodine may have been distributed over the whole body of the adult fish and not confined to the thyroid gland, it looks probable that iodine occurs in greater concentration in young trout tissue than in old. The goitres in these pond fish were 4.3 per cent. of the total fresh weight.

Infection.

In hatching boxes to which no earth is added, moulds grow on the bodies of dead alevins. A certain number of deformed fish occur in all hatchings and these soon die, together with those fish which have died of yolk-sac dropsy. The growth of moulds is reduced by removal of dead fish and by the practice of adding earth to the hatching boxes. Microscopic examination of dropsical fish shows no parasitic growth of moulds. Altogether, the author felt from the beginning that infection was unlikely to be the prime cause of the disease. The further one investigated the more it seemed that some degree of dropsy was so frequent as almost to give the appearance of normality. Certainly an infection which is chronically present in our hatcheries and which takes several weeks to affect the behaviour of highly sensitive young alevins must present peculiar aspects of morbidity. But in view of Von Betegh's claim to have isolated a specific bacillus it was deemed important to search for it in New Zealand, since, while its discovery would leave open the question whether the dropsy had preceded or followed microbic invasion, on the other hand, its absence would weaken the probability of its pathological specificity in Europe. Two dozen alevins, therefore, were punctured and the sac contents smeared on microscope slides and stained by Gram's method, but no single bacillus or mico-organism was detectable in the smears. A broth culture showed only the ordinary water organisms, apparently as contaminations.

Sac Contents.

Hofer gives no description or analyses of the dropsical fluid, and the author has made only a few elementary observations. As said before, the bluish appearance of the material is due to the colloids, mostly of protein nature. On allowing some of the fluid to evaporate in air clear gelatinous non-crystalline plates result which, when water

or saline is added, becomes milky white and do not go readily into solution. Most of the protein is coagulable by heat and appears to be a mixture of serum albumen and serum globulin. Glucose and chlorides are also present, but quantitive comparisons with non-dropsical tissues have not been made. In the case of salts this, as well as the freezing point of the fluid, may be of interest, since osmotic effects seem to be involved.

Other Causes.

Curators in New Zealand are inclined to believe that the percentage of dropsy varies with different parent fish; and, as would be expected, attribute the abnormality to females rather than males. There is an idea abroad that fish in poor condition produce an excessive proportion of dropsies, but no evidence is known to the author. Injury in stripping and in transport has also been suggested, but again the evidence is in doubt. One would expect injury at stripping to produce death in the egg stage rather than dropsy six or seven weeks later; and it is to be remembered that the alevin is biologically remote from the ovum.

General Discussion.

Unless yolk-sac dropsy is studied from the point of view of the ionic arrangements which maintain and disturb the normal balance of osmotic forces in the tissues the clue to causation is likely to be stumbled on only by accident. In this case the membranes surrounding the yolk appear to have an increasing difficulty in maintaining osmotic equilibrium except in conditions which finally are incompatible with life processes in the cell. The dropsy could result from a mechanical blockage of the venous or lymph return, although examination with the microscope has failed to show any mechanical deformity. In human beings, excess water may be retained in the tissues in heart and kidney disease, but even here the water-logging cannot be simply a mechanical result like a break in a water-course, since that would not increase the total volume but merely shift the fluid from one part to another. Whatever the original departure from normal, the organised life-units, probably proteins, have acquired supernormal water-holding powers. Many workers agree that local alterations in the concentration of hydrogen-ions is an effective agent in making colloids more hydrophilic. Often, the local accumulation of hydrogen-ions is a result of deficient oxidation as when lactic acid accumulates in isolated muscle which is too poorly oxygenated. All vertebrate tissue fluids hold a rich assortment of substances which are available for automatic regulation of the internal medium, but the manner of this regulation is for the most part obscure and presents thorny problems for physical chemistry. It is not understood, for instance, why excess of sodium in tissues causes retention of water, while excess of potassium fails to do so. Again, young tissue is more water-holding than senescent tissue, yet young tissue has an intenser oxygen-use than the old. In the case of yolk-sac dropsy it is to be remembered that not only is water increasingly retained together with easily diffusible substances like chlorides and glucose, but colloids, like serum protein, are also held in the sac. There seems to be either an excessive permeability of capillary or lymphatic walls

on the entrance side or a deficient permeability on the drainage side. But since the same membrane probably does both at the same time the separation of permeability from that of hydrophilic properties is artificial and misleading. Like the water-holding power of colloids, permeability of living membranes is generally regarded as varying with local oxidation and local concentration of hydrogen-ions, but again our knowledge of what actually occurs is inadequate. With oxidative processes one has to remember that concomitant reductive processes are inevitable and the one phrase must be held to include the other. Turning again to the oedema problem in these young trout, it is of interest to note that the condition is local, being prominent in the yolk-sac and not affecting the whole of the body. One imagines that unusual structural changes go on here since, unlike the rest of the fish, its tissue, though young, is shrinking in size. The area of the external sac-membrane is greater than that of the skin which will at first replace it. This regressive process is superficially like a local senescence in which we are accustomed to expect oxidative difficulties. Again, the yolk-sac is the most dependent part of the body, and is, therefore, a collection point for gravity drainage. Possibly, too, the digestive processes on the far side of the inner membrane, which must precede the assimilation of yolk, may have something to do with the limitation of dropsy to this area. The processes which give excessive changes in volume are generally irritative or injurious in nature, although these are no doubt quantitative excesses of what occurs in normal stimulation and response. Irritation of various sorts produces changes in the power to hold water, for example we have swelling in surface tissues as the result of sun-burn, or following a flea-bite, or pleuritic effusion following an infection by pus-forming bacteria. But however various the origins, in the end these new conditions must converge on and use the same mechanisms. It is conceivable that the digestive enzymes which are busy transforming the yolk act also as irritants to the membrane surrounding the yolk. This membrane would need to have a structure resembling the alimentary lumen to withstand intense digestive action. Whatever may be the local factors in this case one has to picture dropsy in general as a condition against which the normal organism is always with more or less difficulty on the defensive. That it occurs no more often is a tribute to the vigour of the adjustment. Most of the slightly affected dropsical fish recovered. Is this because the developing fish passes a crisis by evolving new structures which can transport or use the adjustive material already present in the ovum, or are certain necessary ingredients deficient in the egg now made available from the environment? These latter could only be diffusible salts or radiations such as light. Most tempting is the idea that the critical period for the new hatched trout is when the endocrime organs are not yet in a state of normal balance. Insulin and thyroxin are both known regulators of water balance in the mammalian organism, and no doubt they, with other autacoids, are potent in fish life also. Interesting observations probably lie along this line. At the same time, minute attention might be paid to differences in the ova themselves. Each ovum differs in its genetic constitution from all ova, but with the naked eye few differences are visible. They vary somewhat in bulk and colour and in thickness of

the shell. According to the local curator thinner shelled ova burst before development has proceeded sufficiently far, and such alevins die. An attempt to separate ova into groups based on bulk or density might repay the trouble. The author, having no records on the changes in density during development of the egg, made some observations in 1929, but the results are as yet incomplete. As to the affected alevins, the author was unable to detect any constant stigma. Some were big, others small, some light yellowish green, others much darker, and all variations between seem to occur. If light had been an irritative cause of dropsy one would expect the colouration to present constant features. Among the lines of investigation one would like to look for the disease in other species and genera of fish. If it should turn out that the Salmonidae are singular among fishes in this respect one would be tempted to believe that a disproportion between the salt content of the upstream waters and the ova was playing a part, this again being a consequence of the evolutionary history of the species. In human embryos a condition of excessive ammotic fluid is well-known but the text-books give no information as to the cause. Altogether, one is inclined to believe that yolk-sac dropsy involves fundamental and not accidental processes and that inquiry must be deeply penetrative to give understanding. The problem of recovery from the disease is as interesting and important as the problem of causation.

Conditions at Christchurch Hatchery, 1929.

For the use of other investigators the fullest data available are here given, since it is possible that comparisons may automatically exclude false clues.

(1) Dimensions of boxes, 10 ft. × 10 in. The water is 7 in. deep.
(2) Rate of flow per box, 80 gallons per hour.
(3) Number of ova—8,000 per tray. Two trays per box.
(4) Temperature—12.7°.
(5) Gas content (assumed—see previously).

Nitrogen, Argon } etc.	....	15.98 c.c. per litre.
Oxygen	....	5.68 c.c. per litre.
Carbon Dioxide	....	1.88 c.c. per litre.

(6) Radium emanation, 1.5×10^{-12} C (Milligan and Rogers 4).
(7) Reaction: pH equals 7.36.
(8) Iodine Content—2.3×10^{-9}.
(9) Water, Artesian bore 75 feet deep with content believed to be closely similar to the following figures which have been supplied by Mr. Geo. Gray, late lecturer in chemistry at Canterbury College. Mr. Gray's figures refer to a well deeper than the one used in the hatchery.

Total Solids......83	Volatile—18; Non-Volatile—65	Silicic Acid	20
		NH_3	Nil
Hardness 33.1		Albuminoid Nitrogen	0.01
Chloride 4.7		O_2 required to oxidise	
P_2O_5 ...... Nil		organic matter	0.01

All figures are in parts per million.

The chloride of our artesian supply is noted as being intermediate between that of the small Selwyn river (12.0) and the large

mountain-derived Waimakariri (3.0), both streams being close to Christchurch. As regards hardness the Waimakariri is 26.0 at Courtneys and the Selwyn 31.2 at Coe's Ford. Trout are plentiful in both of these rivers but the reputation of the Selwyn as a trout stream is conspicuous all over New Zealand. It is from the Selwyn that the local Society gets its ova. The Selwyn discharges into the large brackish Lake Ellesmere, which abounds in natural trout food. If one suspected deficiency in salts in the environment to be a cause of dropsy one would not expect to find it in ova whose parents lived in the salt rich Selwyn. No figures of the proportions of the bases are available.

Questionnaire.

In October, 1929, the author circulated the following questionnaire to all the twenty-seven Acclimatisation Societies in New Zealand. Some of these did not hatch trout, but sixteen replies are available for summary:—

(1) Does yolk-sac dropsy occur in your district?
(2) (a) What percentage contract the disease?
 (b) When does it first show and reach a maximum?
 (c) What percentage die of it?
(3) Does it affect both brown and rainbow and salmon?
(4) What is the nature of the water supply in your hatchery? (Is it spring, artesian or river?)
(5) Have you any analyses of the gas and salt content of the water?
(6) What is the temperature of the water?
(7) What are the dimensions of the boxes?
(8) How many ova per box?
(9) What is the volume of inflow per hour?
(10) Where do you obtain your ova?
(11) Are ova from any particular source liable to contract yolk-sac dropsy?
(12) Do you know of any causes or conditions producing the disease?
(13) Do you know of any preventatives?
(14) Do you know of yolk-sac dropsy occurring in natural conditions, and if so, where?
(15) Do any other non-parasitic diseases of fish occur in your district (pop-eye, goitre, etc.?)

Replies Summarised.

(1) The disease was known in all the districts except one. The exception was Nelson, where, possibly, terminology was the difficulty.
(2) (a) 0.1 per cent. up to 4 per cent. Most about one.
 (b) Shows on the average at about eleven days. Maximum is at four weeks.
 (c) As in (a). Apparently they do not count minor grades.
(3) All three contract the disease. Three say that salmon is less susceptible.
(4) All kinds of water. Most are small streams.

(5) The Otago hatchery uses water of very low hardness. No other analyses are available.

(6) Most have variable temperature. The range is from 29°F to 58°F. The mean is 46°F.

(7) (8) (9) The number per cubic foot of water (not allowing for flow) varies between 3,000 and 8,300, but the two that are most crowded claim the lowest percentage of dropsy.

(10) (11) Ova from all localities have dropsy but the percentage varies from year to year. Three say that Southland ova (from Lake Te Anau) are the worst and they are inclined to believe that this is due to lack of attention in transport. The other thirteen replies do not blame locality.

(12) Causes are fairly freely suggested, sometimes confidently, such as:—
- (a) Locality (Southland up to 50 per cent. of deaths when transported)—three say this.
- (b) Pond fish—two say this.
- (c) Lack of aeration—two say this.
- (d) Injury in stripping—two say this.
- (e) Old fish—one says this.

(13) *Preventatives.*
- (a) Black earth—two say this. One says it increases the disease.
- (b) More aeration—two say this.
- (c) Salt solution—two say this.
- (d) Condy's Crystals—one says this.

(14) One says that he once saw in the Otapiri, Southland, two redds, side by side, in one of which were normal alevins and in the other several examples of yolk-sac dropsy. (The author unsuccessfully looked for specimens in the Selwyn district in 1929).

(15) Pop-eye in two districts, but no special incidence of dropsy.

Summary.

A number of alleged causes of yolk-sac dropsy in newly-hatched trout have been investigated, but without confirmation of any. The author inclines to the view that the disease is a quantitative accentuation of a process that occurs normally, and that excessive collection of fluid in the sac is the result of genetic differences in the ova.

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PART 2. JUNE, 1930.

LIST OF PLATES.

Observations on Muehlenbeckia Astoni and Its Seedlings.

By MISS H. M. JENKINS.

[*Read before the Manawatu Philosophical Society, 20th September, 1929; received by Editor, 27th May, 1930; issued separately, 23rd August, 1930.*]

PLATES 39–41.

Muehlenbeckia Astoni Petrie, *Trans. N.Z. Inst.*, 43 (1911), 257, t. 2, was described from specimens collected by Mr. B. C. Aston at Palliser Bay (Ruahine-Cook Botanical District), where it is of somewhat rare occurrence. The erect shrubby habit marks it off from the other New Zealand species of the genus. Petrie thus indicates the differentiae of the species: "This species is a near ally of *M. complexa* Meissn. The stout erect woody canelike shoots, the divaricate and interlacing habit of branching and the thin small obcordate-cuneate leaves clearly mark it off as distinct." His material did not allow of full descriptions of the flowers and fruit. Similar plants were later collected by Mr. Aston on the Awatere River near Seddon, and by Dr. L. Cockayne near the mouth of the Flaxbourne Stream. Mr. W. Martin has recently found that the species is scattered through the north-eastern portion of the north-eastern South Island Botanical District. At Vernon, a little south of Blenheim, I have observed it growing as a member of an open shrubland community under dry conditions, in soil showing a mixture of clay and gravel. Associated plants are: *Discaria toumatou, Hymenanthera dentata* var. *angustifolia, Muehlenbeckia australis, M. complexa* (a low compact form). The present study is based on two selected adult plants (called here A and B), at Vernon. I am indebted to Mr. W. Martin and the late Mr. W. Purdie for photographs of these and their seedlings, and to Dr. H. H. Allan for assistance in preparing this paper for publication.

The two plants correspond in general to Petrie's description but afford supplementary details. Plant A (Pl. 39, Fig. 1), growing about 3 km. from the coast on a steep face of clay and gravel, is about 2.5 m. tall, and slightly more in spread. The diameter of the shoots at 60 cm. from the base averages 18 mm. (28 counts). Most shoots are straight and erect, but a few are zigzag and sloping; both forms terminate in masses of closely interlacing branchlets. An over-topping shoot frequently springs from below the terminal mass, and grows vertically. Leaves occur not only in fascicles, but also alternately along the elongated branchlets, the latter with elongated petioles. The petioles and leaf-margins are reddish brown. The flowers are pistillate, numerous, about 2.5 mm. diam., with a white, greenish or pinkish-green perianth, the edges incurved. There are eight staminodes, thick at their bases, pale green, with pinkish somewhat diversely shaped tips. The ovary is bluntly three-angled and three-grooved,

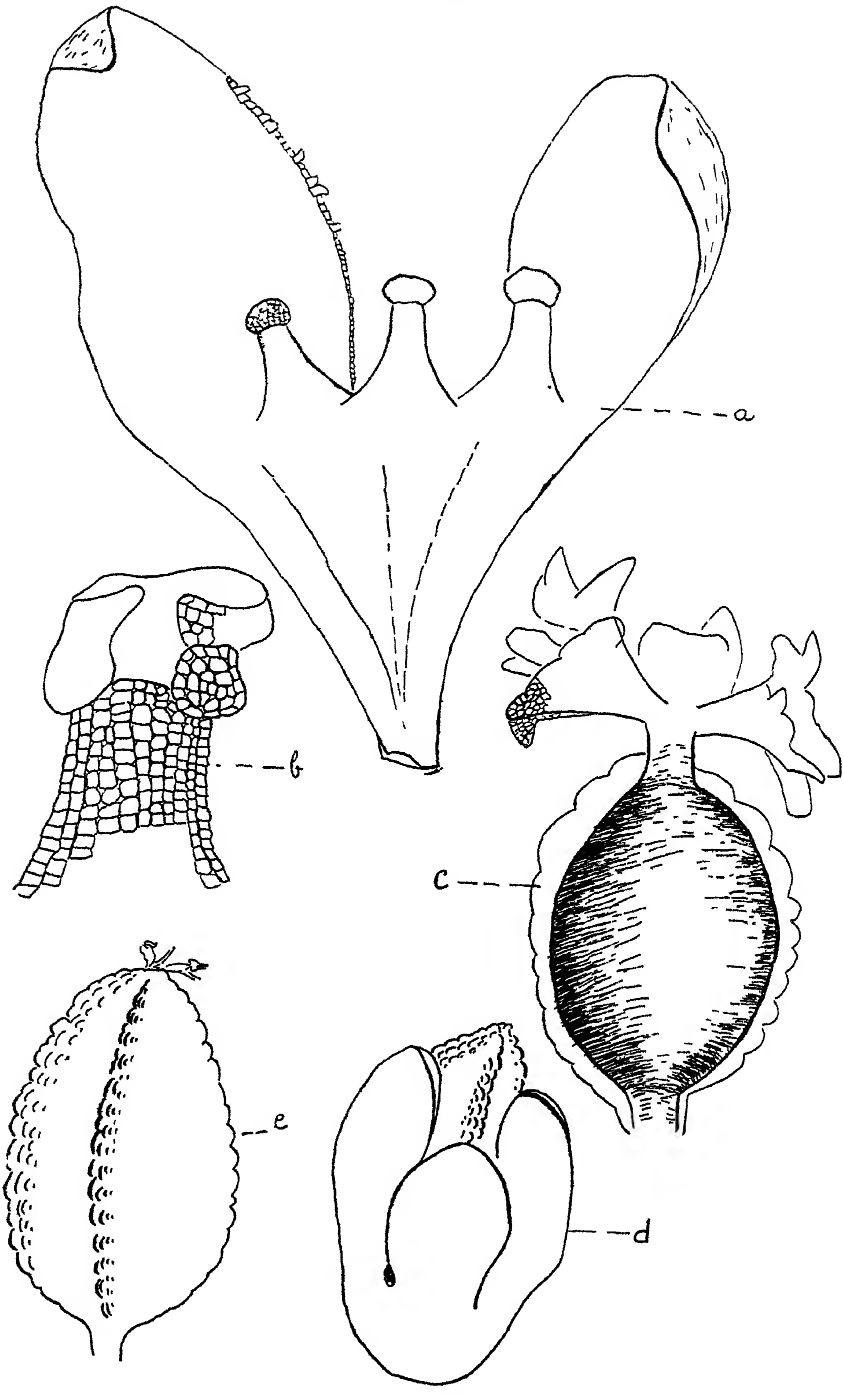


FIG. 1.—*M. Astoni* A. (a) Portion of perianth with 3 staminodes; (b) Upper part of staminode; (c) Pistil; (d) Nut with persistent perianth; (e) Nut.

minutely rugulose, with three spreading fimbriate stigmas (Text-Fig. 1). The ripe nut is 2.2 mm. long, 1.2 mm. broad, three-angled, black or dark-brown, dull and rugulose, almost completely closed by the persistent perianth, which may be unaltered or succulent. All flowers appear to be pistillate, but their minute size and large number make it difficult to be certain that there are no functionally male flowers present, though such must be very few indeed. On male plants pistillate flowers have been occasionally observed. It is to be noted that several male plants of *M. complexa* grow nearby, while until the 1929 season the nearest male plant of *M. Astoni* was 140 m. away.

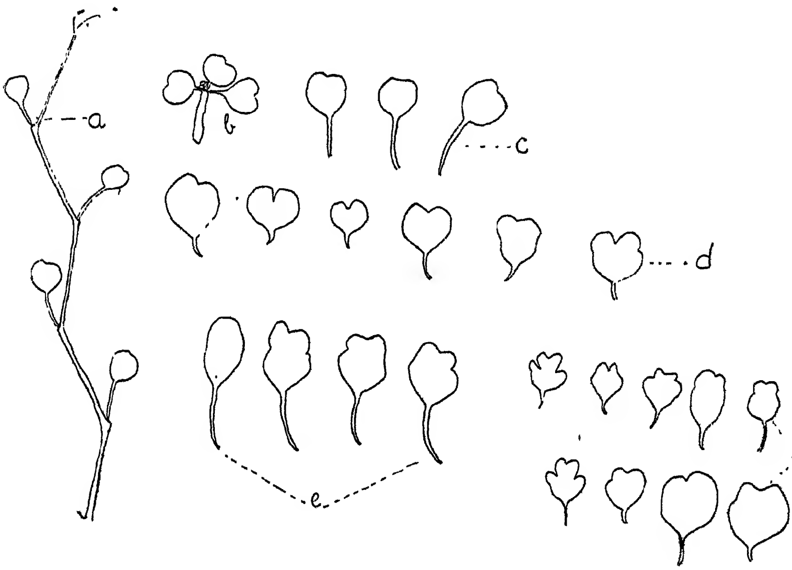


FIG. 2.—*M. Astoni* A. (a) Young branch; (b) Arrested branchlet; (c) Alternate leaves; (d) Fascicled leaves. *M. Astoni* B. (e) Alternate leaves; (f) Fascicled leaves.

Plant B (Pl. 39, Fig. 2) grows 90 m. nearer the coast on flat ground at the edge of a dry gravelly stream-bed, the top 30 cm. of soil being fine silt. It differs from A in having the leaves often variously laterally lobed, (*cf.* Text-Fig. 2), fewer and larger flowers (about 3.3 mm. diam.), a larger nut, and the perianth more often enlarged and succulent. The diameter of the shoots at 60 cm. from the base averages 20 mm. (24 counts). A few fruits were gathered from both A and B at the end of April 1928, and sown immediately in separate tins. Germination was good, taking place in September (seven seedlings from A, and five from B). The plants were placed in their permanent beds in the winter of 1929.

Neither plant produced a uniform progeny, the seedlings falling into three groups. Group I. consists of a single plant, A 1 (*cf.* Pl. 40, Fig. 3). This has developed into a stunted, much and compactly branched plant with stout puberulous branchlets, dark greyish brown

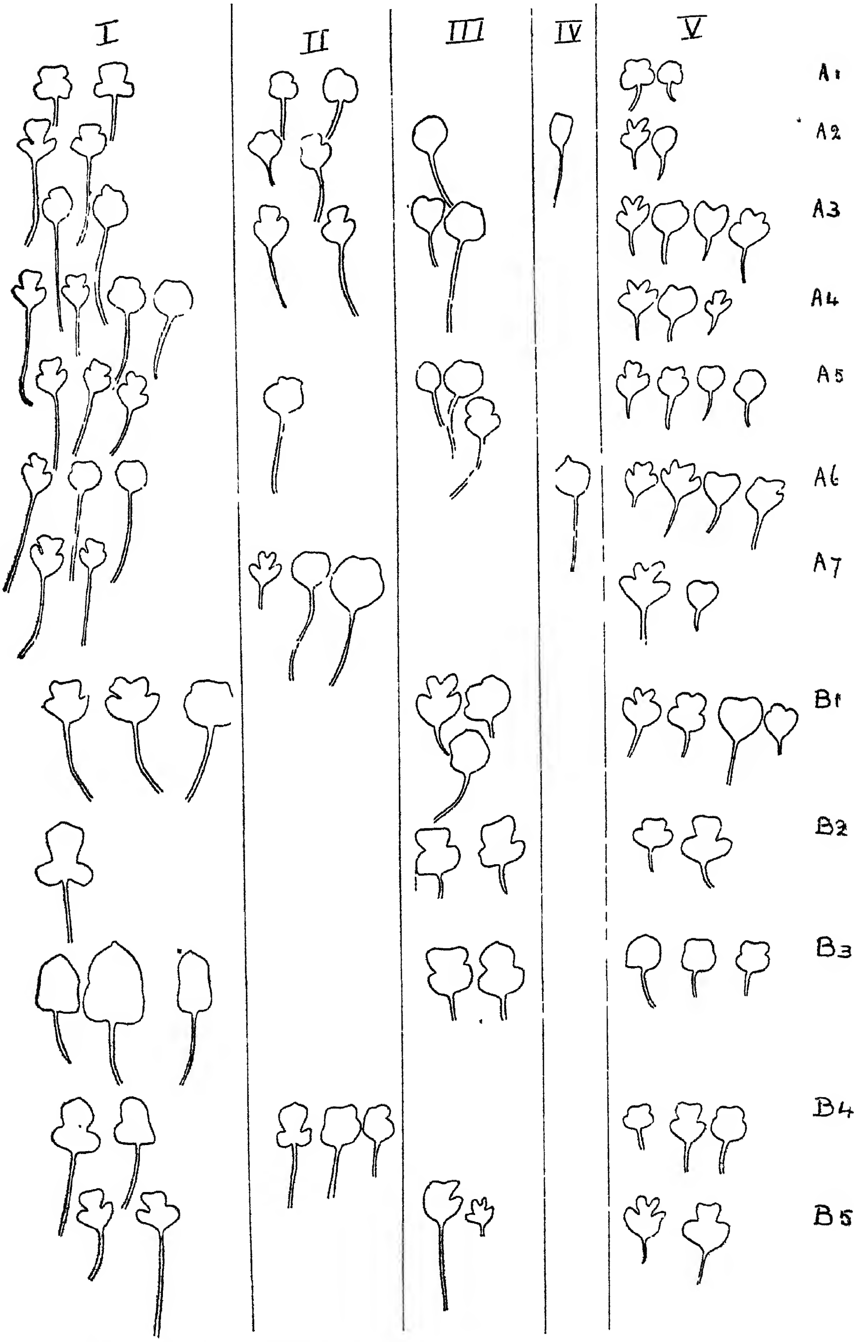
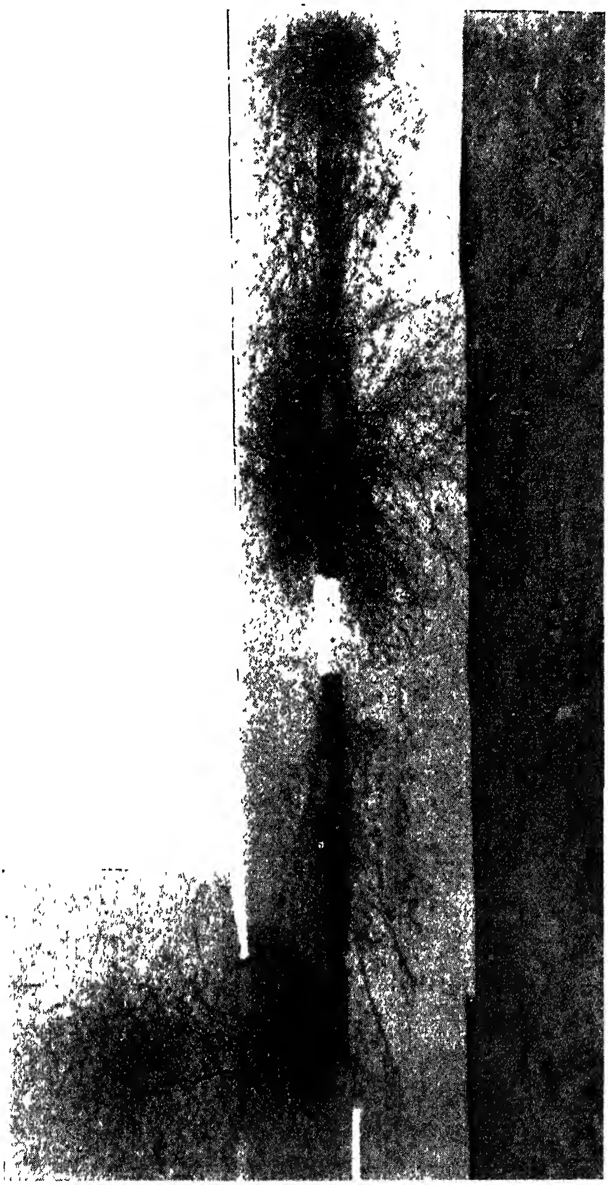


FIG. 3.—Leaves of seedlings of *M. Astoni* A and B. Leaves at middle of March, 1929. I. Very plentiful; II. Frequent; III. Few; IV. Unique; V. Leaves from arrested branchlets at end of April, 1929.

FIG. 1.—*Muehlenbeckia Astoni*, plant A.

FIG. 2.—*Muehlenbeckia Astoni*, plant B. Lower portion, with 30 cm. of soil removed. To right, a young canelike shoot. In front roots of *M. complexa*, from which arise branches scrambling over the plant.

FIG. 3.—Seedlings of *M. Astoni* A.—A1, A2, A3.
(March, 1929).



B_1 B_2 B_3 B_4

Fig. 4.—Seedlings of *M. Astoni* B.—B1, B2, B3, B4. (March, 1930).

stems, subcordate leaves with retuse apices and somewhat lobed margins, the petioles being about 9 mm. long. It has proved to be slightly deciduous in winter, and has as yet shown no sign of flowering. This plant is strongly suggestive of *M. complexa* influence.

Group II. is made up of seedlings from both A and B—A2 to A7, B1, B5. These eight plants, though showing individual differences, have several important characteristics in common, and present a strong *M. Astoni* facies (Plates 40, 41). They have developed into erect spreading shrubs, with slender, flexuous, glabrous, more or less divaricating branchlets, with reddish-brown bark. The leaves are cuneate or rounded at their bases, with retuse apices and lobed or unlobed margins, on petioles about 20 mm. long. All were deciduous in winter. During September-October 1929 all developed from their bases one or more stout, erect, straight shoots of rapid growth. By March 1930 this group presented the appearance of miniature *M. Astoni* plants, all except A2 showing very vigorous growth. A3, A4, B1, B5 bore at this time a few staminate flowers.

Group III. is made up of seedlings B2, B3, B4, and is markedly distinct from group II. These plants are of prostrate or semi-prostrate (B4) sprawling habit (Pl. 41, Fig. 4). The branchlets are very long, flexuous, puberulous, greyish-brown (B2) or dark-brown. The leaves are subcordate, obtuse to somewhate retuse at the apices (or in young leaves somewhat apiculate), lobed (very slightly so in B3) on the margins, with petioles about 12 mm. long. The plants are of vigorous growth, deciduous to a considerable extent in winter. B2 in March 1930 bore a few staminate flowers, which were larger than those in group II. There was thus in this group a marked approach to *M. complexa*. Both in group II. and group III. the leaves showed a good deal of polymorphy (Text-Fig. 3).

The features shown by the 12 seedlings suggest the following possibilities:—

(1) *M. Astoni* may pass through a distinct juvenile form, as is known to occur in some other species of the genus. (2) Hybridization has occurred with *M. complexa,* and perhaps with *M. australis.* (3) The parent plants may themselves be hybrids, their seedlings showing segregation. It is unlikely that epharmony has played much part, as the seedlings were grown under conditions as similar as possible to those of the parents. The matter can be definitely decided only by experiment, but the indications appear to be that *M. Astoni* does pass through a juvenile form. The character of the fruits, unlike those of any other New Zealand species, speaks for the specific distinctness of *M. Astoni.* The seedlings of group III., especially, strongly suggest, however, that *M. Astoni* has hybridized with *M. complexa.* Again, the frequent lobing of the leaves in the adult B, its fewer larger flowers and fruits, suggest that this plant may itself be a hybrid segregate very close to *M. Astoni.* It is hoped to throw further light on the problems by controlled pollinations.

On the Names of New Zealand Periwinkles.

Melarhaphe oliveri n. sp.

Suter, in the *Manual of the New Zealand Mollusca,* 1913 (pp. 187, 188) has used the name *Litorina cincta* Q. and G. and *mauritiana* Lamk.. for our two common species. Iredale (*Trans. N.Z. Inst.*, vol. 47, p. 447, 1915) preferred *Melarhaphe* Menke as the generic name and rejected *mauritiana* as inapplicable to the austral forms. He stated that the "next name is *L. unifasciata* Gray, 1826, given to an Australian shell," but noted that "the Neozelanic shell may prove subspecifically separable." In 1926 (*Trans. N.Z. Inst.*, vol. 57, p. 375) I acted on this suggestion and rejected *unifasciata* as a New Zealand form. Owing, however, to a curious and unpardonable misconception of species I described the wrong shell. This was kindly pointed out to me by Mr. W. R. B. Oliver, of the Dominion Museum, who suggested that according to my figure, I had not renamed the New Zealand "*mauritiana*" at all, and that my *zelandiae* n. sp. was a synonym of *cincta* Q. and G. On looking up the *Voy. Astrolabe,* vol. 2; Pl. 30, Figs. 20, 21, I found that this was certainly the case, and that ever since I began collecting I had reversed the determinations of these two species. Accordingly, *Melarhaphe zelandiae* Finlay, 1926 sinks into the synonymy of *M. cincta* (Q. and G., 1833); neither Mr. Oliver nor myself can find any prior proposition of the combination *Litorina cincta,* so that my name is of no use whatsoever.

As the "*mauritiana*" form in New Zealand is thus still without a name, I now propose for it the name *Melarhaphe oliveri* n.sp., selecting a holotype (in my collection) from Hampden, East Coast of the South Island, and referring for a general description and a good figure to Suter, 1913 (*Man. N.Z. Moll.*, p. 188) and Bucknill, 1924 (*Sea-Shells of New Zealand,* p. 37; Pl. 7, No. 22). I have compared New Zealand specimens (from Cape Maria, Auckland, Wellington, Hampden, Dunedin, and Taieri Beach) with Australian shells (from Sydney, N.S.W.; Mornington, Vic.; and Yorke's Peninsula, S.A.) and find the following differences:—The New Zealand species differs in its smaller shell, higher and more slender spire, with almost straight instead of distinctly convex whorls, notably smaller aperture, and darker more prominent and better defined blue band, which is not just at the peripheral angle but a little above it. The Sydney (Peronian) specimens differ a little from the Mornington and Yorke's Peninsula (Adelaidean) ones, but not nearly to the extent that they all differ from the Neozelanic shells.

The name *Litorina diemenensis* was proposed by Quoy and Gaimard for a Tasmanian species, but New Zealand specimens were also referred here by those authors. It was described as "caerulescente . . . . long 51," and with a "bandalette," which fixes it as the *mauritiana* type of shell, but Tasmanian specimens seem to be allied to *unifasciata* rather than to *oliveri.* The name is sunk in synonymy by Australian writers, and May's figure (*Illust. Ind. Tas. Shells,* 1923; Pl. 22, Fig. 19) shows a very Adelaideanlike shell.

Oliver has noted (*Trans. N.Z. Inst.*, vol. 54, p. 498; 1923) that the New Zealand "*unifasciata*" is not found below low-water level,

neap tides, and has in the same paper made many other interesting observations on its habits and ecology. My thanks are due to him for discovering my error, and I am pleased to bestow his name on this wide-spread New Zealand periwinkle.

Genus Nobolira Finlay.

Powell has recently proposed (*Trans. N.Z. Inst.*, vol. 60, p. 537, 1930), a new subgenus *Adolphinoba,* genotype *A. finlayi* Powell, for Noboliras with "thin simple peristome, not thickened and duplicated." This was done under misapprehension of these characters in the genotype of *Nobolira, Lironoba polyvincta* Finlay, which is much closer to *finlayi* than it is to *bollonsi,* described by Powell as a true *Nobolira.* There is, however, every gradation between the extremes of aperture he figures, and no subordinate group can be set up on this account. He has since agreed with me (*in litt.*) that *Adolphinoba* is a synonym.

Larochella alta Powell.

I can record this species, described from 6-12 fathoms, Mangonui and Awanui Bay (*Trans. N.Z. Inst.,* vol. 57, p. 540; F. 6; 1927) also from 25 fathoms off the Hen and Chicken Islands, Hauraki Gulf. The two specimens from here show no difference at all from Awanui Bay shells. Powell supposed that *Larochella* was a seaweed-frequenting genus, evolved from the deeper water sand-frequenting *"Aclis" succincta* Suter, but it appears that the bathymetric range of *Larochella* is greater than he thought.

Linemera gallinacea n. sp. (Fig. 41).

Shell fairly large for the genus, tall, fairly wide, with subobsolete spiral sculpture, strong axials, weakening on later whorls, and an almost smooth base. Embryo well developed, of two smooth and rather globose whorls, ending abruptly in a sudden contraction, generally followed almost immediately by the first axial rib. Succeeding whorls 4½, faintly convex; the early ones flat, with a narrow horizontal shoulder and blunt angle almost at the upper suture, fading out on lower whorls, which becomes cut in more at lower suture. Axial ribs on first two whorls strong, wide, and well-spaced (own width or more apart), on subsequent whorls progressively weaker, narrower, and closer (interstices becoming only one half to one-third their own width on penultimate and last whorls), 14 ribs on first whorl, 20 on second, 24 on third, variable and irregularly developed on body whorl. At first no spiral sculpture, then a faint groove on the subangled periphery just above lower suture, on penultimate and body whorls this becomes a well marked groove bordered by two narrow spiral cords, sharply marking off the flatly convex base; the axial ribs stop immediately below second of these cords, and just below that again is sometimes a third weaker spiral cord emerging from suture (generally absent); rest of base practically smooth except for obscure spiral markings indicating indefinite ribs. A distinct umbilical chink is present, over which the pillar is slightly reflexed and is then continued to form a distinctly

effuse anterior lip to the suboval inclined aperture, behind which is a weak varix. Peristome continuous, sharp. (Rarely, a fourth spiral cord may appear on body whorl just above the two peripheral threads).

Height, 3.1 mm.; width, 1.6 mm. (type).

Height, 3.7 mm.; width, 1.8 mm. (paratype).

Height, 3.5 mm.; width, 1.7 mm. (Poor Knights paratype).

Locality—25 fathoms, off Hen and Chicken Islands, type and many others; also from 35 fathoms, Colville Channel (sent to me by Odhner as "*Aclis semireticulata* Suter," *vide* Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 404, 1926), 38 fathoms off Cuvier Island, and 60 fathoms off Poor Knights Islands. The numerous specimens from the last named locality are on the whole a trifle more slender, and have the sculpture on the last whorl slightly weaker, but are not worth separating as a bathymetric variety.

Type in Finlay collection.

This is the largest New Zealand species of *Linemera*, and is not very closely related to any other, though probably an offshot from *gradata* (Hutton). From that species it is easily distinguished by its larger size, suppressed spiral sculpture, and smooth base. The *pingue* and *gradata* series, though having many points in common, are evidently by now quite distinct, since a new species, which is a *pingue* relative, lives together with *gallinacea* as a perfectly separable form: no hybrids have been seen. There do not, however, seem to be sufficient grounds, at least at present, for erecting a subgenus for the *pingue-exserta* group.

Linemera gradatoides n. sp. (Fig. 40).

A Recent descendant of *gradata* (Hutton), nearer to it than is any other Recent species. Apex the same, but a little less depressed; 3¾ shell whorls follow. Whorls not quite so flat (due to the stronger and more median second spiral); suture still more canaliculate, the peripheral and shoulder angles being further from the suture; margined above but not below. Axial ribs a little stronger, more distant (1½ times their width apart), 16-17 on penultimate whorl, hardly more crowded near aperture, otherwise as in *gradata*. Four spirals on spire whorls, the lowest as in *gradata*, the upper three more crowded together, subequal and subequidistant; the difference is most noticeable with the second spiral, which is strong and submedian instead of subobsolete, low down, and close to third. The first and second become wider apart on body whorl, and a very weak interstitial riblet may develop between them. The fourth spiral continues strongly on base below periphery, as in *gradata*, and 4 more subequal, close, and subequidistant smooth cords occupy the rest of the base; the groove between peripheral spiral and the one below is relatively deeper and wider than in *gradata*, and the segregation of the basal spirals is thus better marked. Umbilical chink and aperture as in *gradata*.

Height, 3 mm.; width, 1.6. mm.

Locality—50 fathoms off Oamaru, many specimens.

Type in Finlay collection.

Rissoina larochei n. sp.

Shell very small for the genus, distantly obliquely costate. Embryo relatively large, of about two smooth whorls, the tip rather prominent and inturned, the next whorl somewhat swollen. Four and a-half whorls follow, fairly regularly convex, shoulder slightly flattened. Ten axials per whorl, their own width or a little more apart, in the shape of a shallow reversed S, but decidedly oblique, sloping forwards lower down, weaker and more distant on shoulder, vanishing on base below the convexity. Whole surface appears smooth, but is densely crowded with minute crowded spiral grooves, only perceptible under high power. Aperture like *chathamensis,* but basal lip projecting further down and out; relatively large for so small a shell.

Height, 2.9 mm.; width, 1.3 mm.

Locality—12 fathoms, Doubtless Bay, two shells dredged by W. La Roche.

Type in Finlay collection.

The only other *Rissoina* of this size in New Zealand is *rufolactea* Suter, which has a wider shell, flatter whorls, and much more numerous axials; its whole aspect is different.

Rissoina powelli n. sp. (Fig. 37).

Shell moderately large for the genus, with weak axial sculpture, polished and shining. Embryo dome-shaped, milk-white and glossy, of about two rather large whorls, merging imperceptibly into adult shell, tip somewhat flattened and inturned. Whorls 6, sides straight except for a slight bulge just at suture, spire straight. Axials normally about 16 per whorl, but generally irregularly developed, becoming more numerous and subobsolete on body whorl, merely very low raised ridges, 1½-2 times their width apart, somewhat like these of *anguina* Finlay, but a little coarser, extending in almost straight lines from suture to suture and vanishing below periphery on body whorl. Surface apparently quite smooth and shining, but irregular spiral scratches are visible under a high power, more regular and distinct on base. Colour uniformly greyish white. Aperture as in *chathamensis,* but somewhat more open.

Height, 8 mm.; width, 3.5 mm. (type).

Height, 7.9 mm.; width, 3 mm. (paratype).

Locality—60 fathoms, off Poor Knights Islands, numerous specimens.

Type in Finlay collection.

Very like a *Zebina* with axial sculpture, but lacking the aperture denticles of this genus. A more Eulimoid aspect than any other New Zealand species, and one of our most attractive Rissoinas.

Rissoina fictor n. sp. (Fig. 38).

Shell very tall and slender, smooth except for spiral grooves. Embryo as described for *powelli,* forming a rather blunt top to the shell. Whorls about 5, practically flat. Spire acicular, very high for the genus, more than twice height of aperture, outlines straight.

No axial sculpture. Dense and rather prominent spiral grooving covers whole surface. One narrow brown spiral band just above middle of whorls. Aperture as in *chathamensis,* but more sharply angled above and below.

Height, 5.6 mm.; of aperture, 1.7 mm.; width, 1.9 mm.

Locality—38 fathoms, off Cuvier Island.

Type in Finlay collection.

This is practically an *Austronoba* in appearance, but has a Rissoinid aperture. The spiral grooving, colour band, and high spire are quite as in *Austronoba,* which, however, is smaller, and generally has axial ribs on upper whorls, and not so flat a spire. The only other New Zealand *Rissoina* with obsolete axials is *achatina* Odner but this has lightly convex spire outlines, a quite differently shaped body whorl, and very inconspicuous spiral ornament.

Rissoina fucosa n. sp. (Fig. 43).

Shell fairly small, strongly axially costate. Embryo apparently as in *chathamensis* (*i.e.,* of 1½ smooth depressed whorls, nucleus prominent), but somewhat smaller. Adult whorls 5½, markedly convex, sutures well cut in, not margined. Axials 13 per whorl, very strong and distant, 2½-3 times their width apart, slightly oblique from suture to suture, strong over whole body whorl right down to basal and inner lips, just before reaching inner lip they curve sharply over almost at right-angles, and form a weak but distinct fasciole ridge surrounding the inner lip and marking previous channels of apertures. Spirals practically absent except on base, where they form extremely fine and numerous spiral ridges. Aperture as in *chathamensis,* but much more deeply and narrowly channelled below.

Height, 4.8 mm.; width, 2 mm.

Locality—38 fathoms, Cuvier Island.

Type in Finlay collection.

This species strikingly simulates *Rissolina* Gould in the strong sculpture and tendency to form a fasciole, but the latter feature is very much stronger in typical *Rissolina,* and the aperture correspondingly much more deeply and laterally notched; the sutures and apex, too, are different from *Rissolina.* The species seems really to be closely related to *chathamensis,* but apart from the fasciole (which *chathamensis* never has), it has fewer and more distant axials, fewer and less conspicuous spirals, an unmargined suture, slightly more convex whorls, and a smaller test.

Key to the New Zealand species of *Rissoina*.

Shell small (under 4 mm.)
 15 axials on last whorl .. .. *rufolactea* Suter.
 10 axials on last whorl .. .. .. *larochei* Finlay.
Shell larger (over 4 mm.)
 Shell very large and stout (width over 4 mm.), no
  axials, spire somewhat mucronate .. .. *zonata* Suter.

Shell more slender (width generally under 3 mm., not exceeding 3.5 mm.), spire straight or lightly convex.	
Axials obsolete.	
Spire more than twice height of aperture, spiral grooves prominent	*fictor* Finlay.
Spire less than twice height of aperture, spirals very indistinct	*achatina* Odhner.
Axials well developed, no fasciole.	
Axials weaker or disappearing on lower half of whorls, about 24 per whorl, shell rather short	*anguina* Finlay.
Axials generally strong over whole surface, sometimes weakening on body whorl, about 15 per whorl, shell higher . . .	*chathamensis* Hutt.
Axials irregular, low and weak from suture to suture, normally 16 per whorl, shell shining, rather large and tall . ..	*powelli* Finlay.
Axials very strong, turning over on a basal fasciole, after the style of *Rissolina*	*fucosa* Finlay.

True *Rissoina* is unknown from the New Zealand Tertiary, apart from the record of *chathamensis* from Castlecliff. My *R. perplexa* (*Trans. N.Z. Inst.*, vol. 55, p. 489, Fig. 11, 1924), from Clifden, has a Rissoid aperture, and does not belong to the Rissoinidae. It may be transferred for the present to *Haurakia*, though it is improbably congeneric with *hamiltoni*, the genotype. *Rissoina* (?) *obliquecostata* Marshall and Murdoch (id., vol. 52, p. 128, Pl. 6, Fig. 1, 1920), from Hampden, may be associated with *Aclis costellata* Hutton near *Zeradina* Finlay; these two will later be separated from that group, but as I have no good specimens of either, I leave them there at present.

Nozeba mica n. sp.

Shell very minute, milk-white, shining. Apex planorbid, quite flattened, but the whorls convex and the sutures well marked; thence disproportionately increasing downwards. Four whorls altogether, the last occupying most of the shell, quite different in shape from the preceding whorl, which is very convex, while the last whorl has a straight steep slope below suture and then is lightly convex to the sloping base. Surface at first sight perfectly smooth, polished and shining, but a high power shows 4-5 distinct grooves on base round canal, and extremely minute spiral grooving above periphery, which seems to be smooth. Suture well marked, margined below. Aperture pyriform, completed across parietal wall, nowhere callused, basal lip well rounded, hardly effuse. Columella concave. A minute but distinct umbilical chink.

Height, 1.4 mm.; width, 0.8 mm.

Locality—25 fathoms, off Hen and Chicken Islands.

Type in Finlay collection.

The minute size is the chief distinguishing feature of this species. Otherwise it resembles *coulthardi* (Webster) in sculpture and

aperture, but has a lower spire, unthickened aperture at parietal wall, and much shallower basal notch. All the specimens are about the same size and show an adult aperture.

Socienna maoria n. sp. (Fig. 45).

Shell small, slender, elegantly clathrate. Embyro of two whorls, the first somewhat depressed, all but the tip ornamented with numerous close axial riblets, less than their own width apart. Adult whorls 7, slightly convex, sutures well cut in, finely margined above. Four spirals per whorl, the lower three always stronger, narrow and rather sharp ridges, 3-4 times their width apart, a fifth similar one emerges from suture on to base, forming a sharp undulation there, below which base is concave and smooth except for a faint spiral margining the basal notch fasciole. Spirals reticulated by similar axials (perhaps slightly weaker, about 17 per whorl, sloping slightly backwards, slightly wider apart than spirals so that the enclosed pits are a little oblong; intersections nodulous. Aperture open, oval-oblong, outer lip thin, practically no basal lip, almost the whole of the space being taken up by a very deep U-shaped notch in the concave base; pillar short, a little twisted and bent to left at its base, slightly excavated above.

Height, 4.5 mm.; width, 1.2 mm.

Locality—6 fathoms, Doubtless Bay.

Type in Finlay collection.

Very like the Tasmanian *S. apicicostata* May (*Proc. Roy. Soc. Tas.* for 1919, p. 64, Pl. 16, Figs. 21, 21a), the genotype, but with an extra rib below suture and more convex whorls; the basal rib also is not smooth but noduled like the rest.

Seilarex exaltatus Powell, just described from 5-6 fathoms, Great Barrier Island (*Trans. N.Z. Inst.*, vol. 60, p. 538, Fig. 3, 1930) is a true *Socienna*, differing from *maoria* in having a four-whorled apex, and the central spiral keel more prominent than the others. The type of *Seilarex* is a very much larger shell with no axial sculpture, though the protoconch and aperture details indicate a relationship. I have a typical ancestral *Seilarex* n. sp. from Balcombe Bay (Australian Balcombian) and two new species of *Socienna* from Target Gully (New Zealand Awamoan), so the two lines have long been separated and should be nominally distinguished.

Zeacolpus mixtus n. sp. (Fig. 42).

Shell small, similar to *pagodus* (Reeve) in habit and painting, but less strongly keeled. The species of this group vary principally in the relative strength and development of the original four keels, if these are lettered A, B, C, and D, from the top downwards, the sculpture of the various forms may be described as follows. In all the species C is the first to appear, often as the continuation of a keel on the protoconch, and is the strongest; D appears after the embryonic stage, and soon becomes nearly as strong as C; A and B appear a little later as weak threads, which may become strong on later whorls. In *vittatus*, C and D always remain a little stronger and wider apart than A and B, but none of the keels become promi-

nent, and the intercalation of subsidiary spirals, and the tendency to bulge a little at A gives the whorls a flattish, evenly sculptured appearance. In *pagodus*, C begins as a very strong keel and is always the most prominent, B eventually becoming the next most conspicuous, so that the whorls appear fairly sharply keeled at about the lower third, with a very slight bulge at the upper third. In *fulminatus*, A and C always remain the strongest, the latter rather more prominent; B and D are always inconspicuous, hardly stronger than the intercalated spirals, while a fairly strong cord develops at the lower suture and finally on the periphery of the base. In *ahiparanus* Powell (*Trans. N.Z. Inst.*, vol. 58, p. 297, Pl. 34, Fig. 4, 1927), everything remains subordinate to C, which is everywhere much stronger even than in *pagodus* (and thus very reminiscent of the Tertiary *albolapis* Finlay), A, B, and D being hardly discernible from the subsidiary spirals; a strong keel finally emerges from suture on to periphery of last whorl. In *mixtus* n. sp., the early stages are as in *vittatus* (C and D subequal and fairly strong, A and B weak); on the lower half B, C, and D are subequal, C forming a weak carina on the whorls, and A is indistinguishable from the secondary spirals; there is no sub-sutural bulge, so that the whorls are much more convex than in *vittatus*, but not so sharply angled as in *pagodus*, the angle, too, being submedian. The last whorl tends to be flatter, with the keels weaker. Aperture and base almost as in *vittatus*, *pagodus* having a more oval opening.

Height, 22 mm.; width, 6 mm.

Locality—60 fathoms, off Poor Knights Islands.

Type in Finlay collection.

An obvious derivative of *vittatus* (Hutton) but though living together with it and *fulminatus* (Hutton) (both of which I have from 60 fathoms, Poor Knights), separable at sight, and constantly distinct. For comparison and ease of identification, figures are here presented also of *vittatus* (Hutton) (Fig. 39), from 60 fathoms off Poor Knights Islands; *pagodus* (Reeve) (Fig. 44), from 25 fathoms, off Hen and Chickens; and *fulminatus* (Hutton) (Fig. 36), from 60 fathoms, off Poor Knights Islands.

Zegalerus tumens n. sp.

Shell very close to the Pliocene *Z. crater* Finlay (= *alta* Hutton, preoccupied), but with more globose whorls. *Crater* is generally a not very high shell, with almost straight sides, the sutures inconspicuous. *Tumens* is very elevated, but the whorls are still strongly convex, and the sutures well marked. Surface worn, but shows traces of coarse pitting. No false umbilicus, only a callus pad. Septum shows faint concentric striation.

Height, 14 mm.; width, 27 mm.

Locality—Cape Maria van Diemen, four specimens.

Type in Finlay collection.

Z. crater has been reported by me as occurring at the Chathams. The two Recent specimens I have from there differ from *tumens* in the same points as do Pliocene topotypes, so that *crater* seems still to exist in a southern habitat, *tumens* being a northern geminate form.

Cochlis vafer n. sp.

Natica gualteriana of Australian authors.

Powell (*Trans. N.Z. Inst.*, vol. 57, p. 560, 1927) has lately described a New Zealand shell from the north Cookian region as *C. migratoria* (see Figs. 34, 36), stating that it is identical with the Peronian *gualteriana* auct., which he shows is not really Recluz's species. I do not think, however, that the specific identity of the New Zealand and Australian shells can be upheld; apart from the unlikelihood of finding an animal so responsive to environment as a Naticoid unchanged on both sides of the Tasman Sea, comparison of actual specimens shows valid differences. Specimens from Shell Harbour, N.S.W. (whence Powell made his Australian identification) resemble *migratoria* very closely, but are slightly more vertically compressed in whorling, and the base is thus flatter. Especially is the nick between funicle and parietal callus much deeper, so that the umbilical furrow and notch in pillar form a full semicircle, instead of only a quarter to a third of a circle as in *migratoria*. The sutural furrows tend, on the earlier whorls at least, to be coarse and further apart. Colouring and size are the same in the two species.

Height, 15 mm.; width, 14 mm.

Locality—Shell Harbour, N.S.W.

Type in Finlay collection.

Nodiscala zelandica n. sp. (Fig. 35).

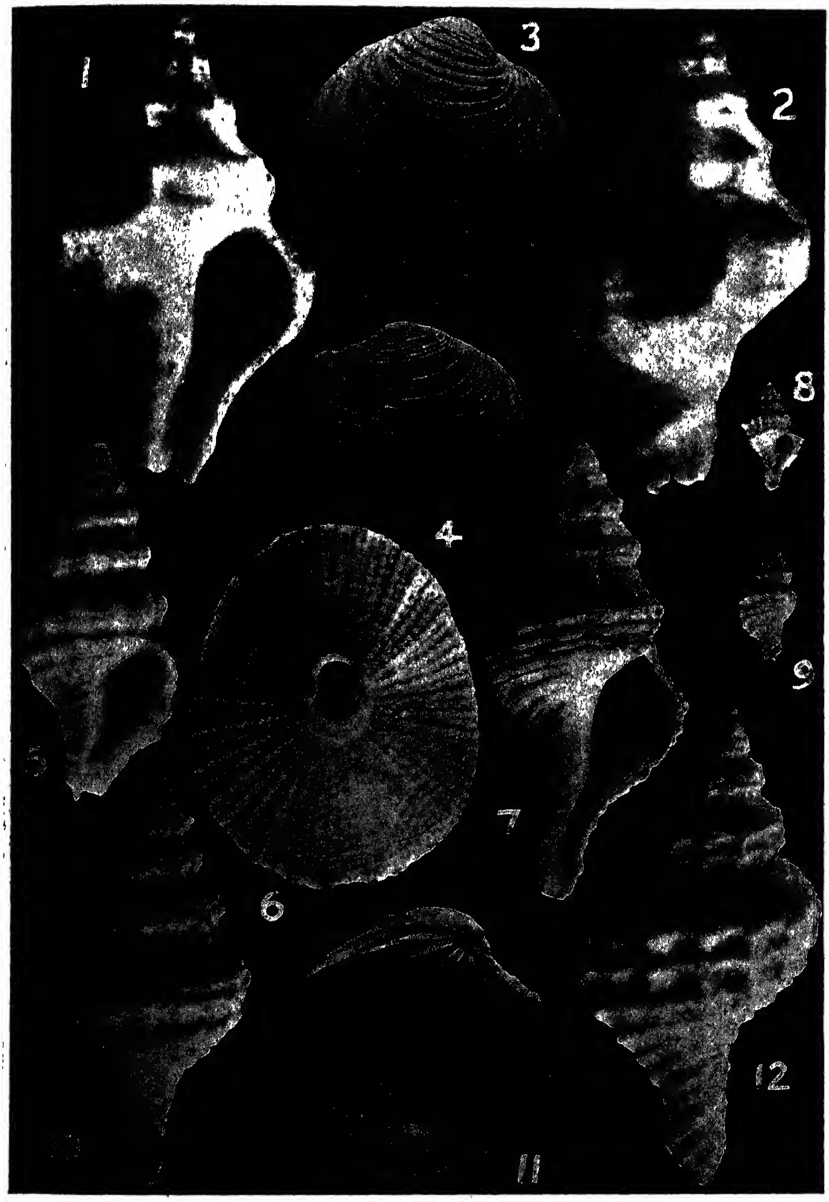
Shell small, axially costate and spirally punctured. Embryo worn, but apparently paucispiral and smooth. Whorls 7, convex, slightly excavated below suture, which is well marked, and somewhat margined below by a low band; the last whorl disproportionately bulging. About 18 axials per whorl, extending evenly across whorls, about twice their width apart, somewhat projecting at upper suture, continued down to fasciole on base, but weaker below periphery. Whole surface with extremely dense and weak spiral threads of irregular width, with linear interstices, stronger anteriorly; interstices everywhere thickly dotted with punctures. Same sculpture on base, which is regularly convex, no basal disc. Aperture obliquely oval, lips broad and quite flat, a narrow smooth and shining inner ring encased in a much broader spirally grooved and punctured outer band. A distinct but tiny fasciole marked by a slight swelling on base close to and sub-parallel with inner lip, a shallow umbilical groove between; this is shown at aperture by a slight thickening at meeting of basal and inner lips to form a tiny pad.

Height, 10 mm.; width, 3.7 mm.

Locality—75 fathoms, off North Cape.

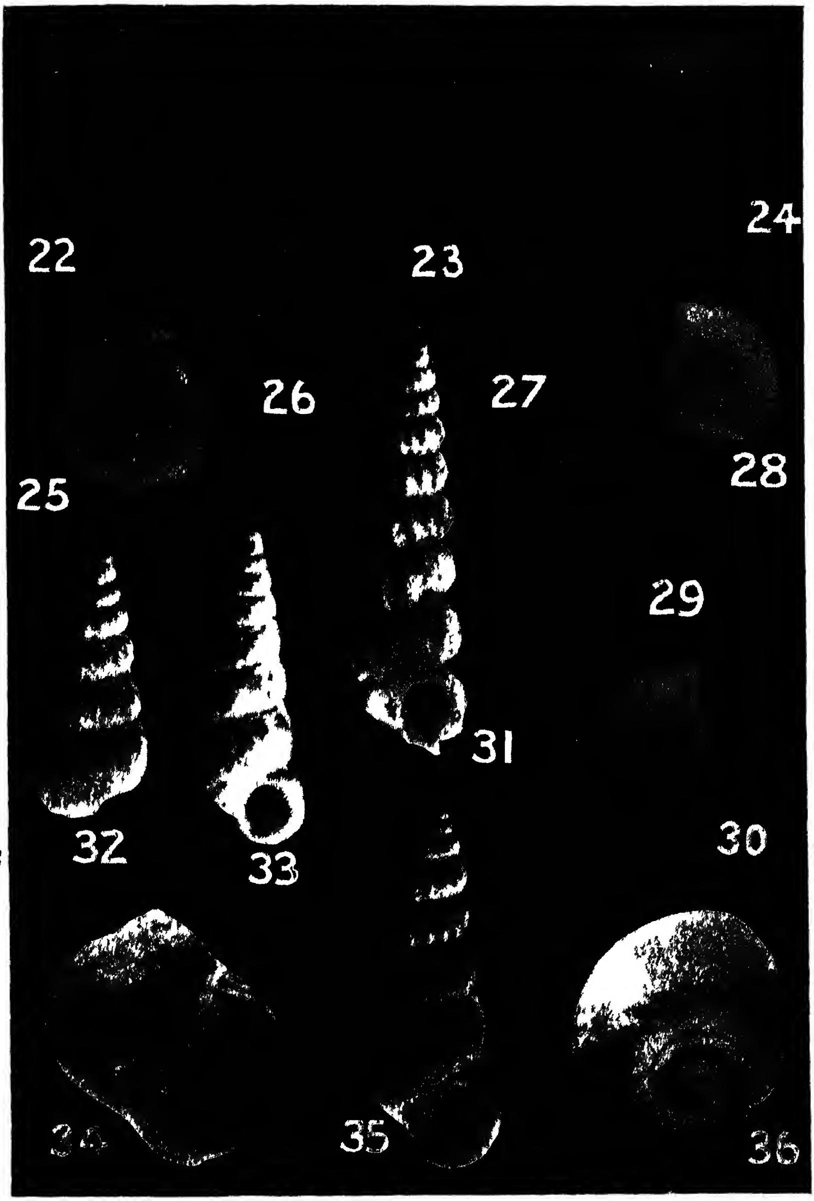
Type in Finlay collection.

Accurate generic location of the Scalidae is very difficult in the absence of actual genotypes. Cossmann's treatment in the *Ess. Pal. Comp.*, vol. 9, 1912 is not always dependable or lucid, and the multitude of generic names proposed (probably correctly) by the specialist de Boury makes elimination no easy task. *Crassiscala* de Boury type: *Scalaria francisci* Caillat, French Eocene) is treated



FIGS. 1, 2.—*Axymene teres* n. sp.: holotype. × 11.
FIGS. 3, 4.—*Plurigens phenax* n. sp.: paratypes; 3 × 4/5, 4 × 1.1.
FIG. 5.—*Zeatrophon tmetus* n. sp.: holotype. × 3.
FIG. 6.—*Monodilepas otagoensis* n. sp.: holotype. × 5.
FIG. 7.—*Zeatrophon caudatinus* n. sp.: holotype. × 5.
FIGS. 8, 9.—*Zeatrophon pulcherrima* n. sp.: holotype. × 1.5.
FIG. 10.—*Zeatrophon tmetus* n. sp.: paratype. × 6.
FIG. 11.—*Plurigens phenax* n. sp.: holotype. × 4/5.
FIG. 12.—*Zeatrophon pulcherrima* n. sp.: Cuvier Id. specimen. × 9.5.

FIGS. 13, 15.—*Microvoluta biconica* (M. & S.): 25 fathoms, Hen and Chickens. × 12.
FIG. 14.—*Inglisella septentrionalis* n. sp.: holotype. × 11.
FIG. 16.—*Bonellitia superstes* n. sp.: holotype. × 9.
FIG. 17.—*Austromitra lawsi* n sp.: holotype. × 4.
FIG. 18.—*Austromitra planatella* n sp.: holotype. × 5.
FIG. 19.—*Microvoluta cuvierensis* n. sp: holotype. × 12.
FIG 20.—*Oamaruia deleta* n. sp.: holotype. × 11.
FIG. 21.—*Microvoluta cuvierensis* n. sp.: paratype. × 12.



FIGS. 22, 23.—*Hochstetteria pinctada* n. sp.: holotype. × 5.
FIG. 24.—*Hochstetteria pinctada* n. sp.: paratype. × 5.
FIGS. 25, 26, 27.—*Hochstetteria meleagrina* Bernard: 50 fathoms, Otago Heads. × 5.
FIG. 28.—*Hochstetteria munita* n. sp.: Lyall Bay. × 5.
FIG. 29.—*Hochstetteria munita* n. sp.: holotype. × 5.
FIG. 30.—*Hochstetteria munita* n. sp.: paratype. × 5.
FIG. 31.—*Murdochella superlata* n. sp.: holotype. × 13.
FIG. 32.—*Funiscala maxwelli* n. sp.: paratype. × 5.6.
FIG. 33.—*Funiscala maxwelli* n. sp.: holotype. × 5.6.
FIGS. 34, 36.—*Cochlis migratoria* Powell: Whangaroa. × 2.4.
FIG. 35.—*Nodiscala zelandica* n. sp.: holotype. × 5.

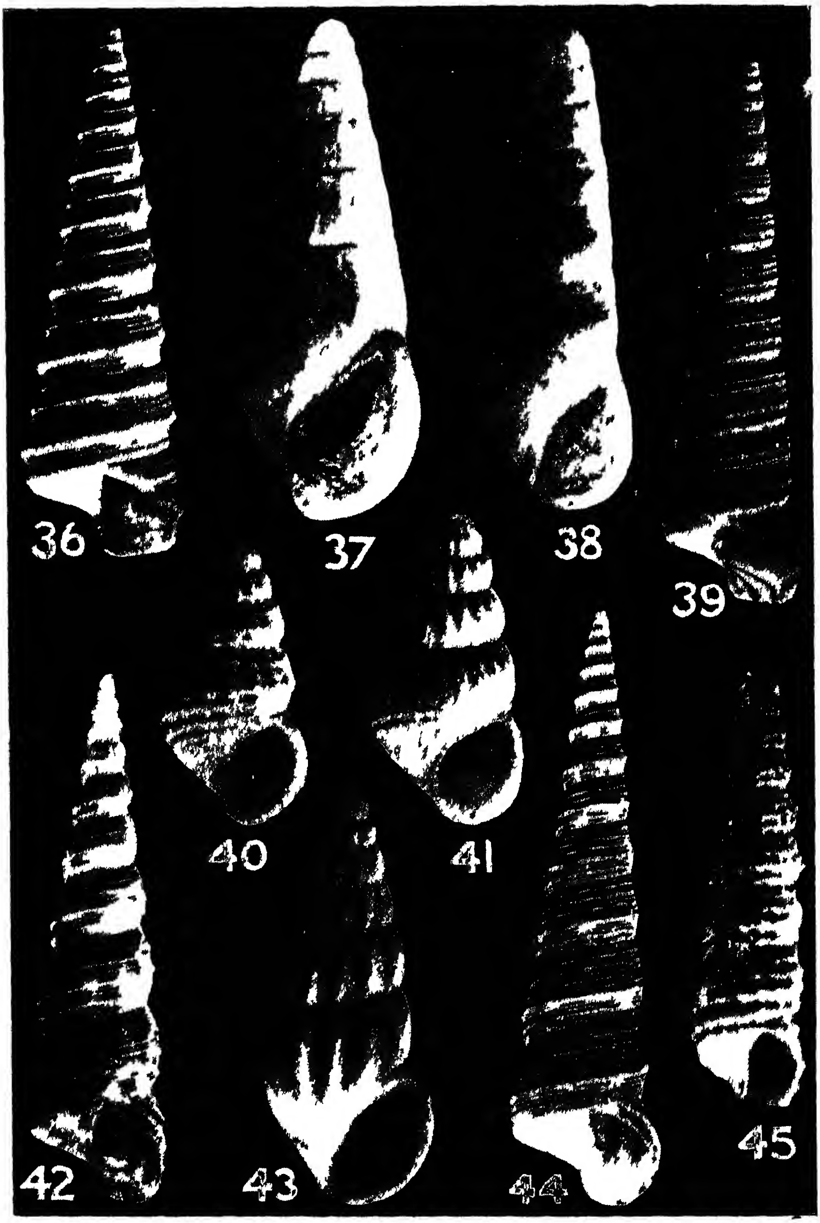


Fig. 36.—*Zeacolpus fulminatus* (Hutton): 60 fathoms, Poor Knights × 3.4.
Fig. 37.—*Rissoina powelli* n. sp: holotype. × 8.6.
Fig. 38.—*Rissoina fictor* n. sp: holotype. × 12.
Fig. 39.—*Zeacolpus vittatus* (Hutton): 60 fathoms, Poor Knights × 3.4.
Fig. 40.—*Linemera gradatoides* n. sp: paratype. × 12.
Fig. 41.—*Linemera gallinacea* n. sp.: paratype, Poor Knights. × 12.
Fig. 42.—*Zeacolpus mixtus* n. sp: holotype. × 3.4.
Fig. 43.—*Rissoina fucosa* n. sp.: holotype. × 12.
Fig. 44.—*Zeacolpus pagodus* (Reeve): 25 fathoms, Hen and Chickens × 3.4.
Fig. 45.—*Socienna maoria* n. sp.: holotype. × 13.5.

by Cossmann as a subgenus of *Granuliscala* of the same author, founded on the common Australian *S. granulosa* Q. and G. The present shell shows little resemblance to *granulosa,* but is very like Cossmann's figure of *francisci;* it certainly belongs to his subfamily Opaliinae, and the absence of the basal disc—a rare feature in other than typical Scalidae— is shown only by *Crassiscala.* Cossmann quotes Eocene, Oligocene, and Pliocene, but no Recent species.

On the other hand, Powell (*Trans. N.Z. Inst.*, vol. 60, p. 541, Fig. 10, 1930) has described as *Pliciscala* (*Nodiscala*) *ahiparana* a new species from 70 f. off Ahipara which is undoubtedly congeneric with the shell here described. His argument and generic location seem very reasonable, so I prefer to use *Nodiscala* until actual genotypes are available.

It is of course absurd to call all our species *Epitonium* or *Scala;* numerous groups are represented in New Zealand, and on the basis of Cossmann's figures and diagnoses I suggest the following locations for some of the species as a first step towards a more correct classification.

Epitonium tenuispiralis Marshall, 1919, *Scalaria marginata* Hutton, 1885, and possibly *Epitonium* (*Clathroscala*) *cylindrellum* Suter, 1917 may be transferred to *Turriscala* de Boury, 1890; type: *Turbo torulosus* Brocchi, Pliocene.

Scalaria nympha Hutton, 1885, to *Funiscala* de Boury, 1891; type: *Scalaria speyeri* Sacco, Oligocene.

Epitonium tricinctum Marshall, 1918, to *Cirsotrema,* near *C. angulata* Marwick, 1926.

Turbonilla awamoaensis Marshall and Murdoch, 1921 is not one of the *Pyramidellidae,* but belongs to *Notacirsa* Finlay. It is close to *oamarutica,* but has much finer spiral sculpture. I have a few specimens from Pukeuri, and one from Target Gully, but it is very much rarer than *oamarutica.*

Funiscala maxwelli n. sp. (Figs. 32, 33).

Shell small, of rather smooth appearance. Embyro of about 1½ whorls, smooth and shining. Subsequent whorls 7, with numerous weak axial ribs and extremely dense spiral grooves. Fifteen-sixteen axials per whorl, irregular and somewhat sinuous, sloping forward a little at upper suture, 2-2½ times their width apart, stopped by the basal disc. Extremely fine regular and dense spiral grooving over whole surface, also on and below basal disc, which is very stout and keel-like, though blunt; it emerges from suture and encloses a rather narrow concave area, just above it is a distinct concavity. Aperture sub-circular, slightly flattened basally by the area within the disc, with a narrow but blunt ring-like edge, outside of which is a moderately thick varix with the spirals running over it; no fasciole or pad at the junction of basal lip and pillar. A few other varices are irregularly distributed over the shell.

Height, 7.8 mm.; width, 2.7 mm.

Locality—50 fathoms, 10 miles E.N.E. of Otago Heads, dredged by Mr. Maxwell Young.

Type in Finlay collection.

This seems quite close to the Pliocene *Scalaria nympha* Hutton, 1885 (which I have not seen), and is probably its Recent representative. The Tertiary shell has more axials, has the basal disc visible on the spire whorls as a thread margining suture, and is apparently shorter.

Murdochella tertia n. sp.

Shell close to *alacer* Finlay in protoconch, closer to *laevifoliata* M. and S. in sculpture. Embyro of two whorls, all but the first half volution with prominent axial ribs, interstices a little wider, extending regularly from suture to suture, otherwise smooth, ending in a very prominent raised varix with a thin sharp edge. Whorls about 5, flatly convex, not keeled, sutures well cut in. All whorls with 3 spirals on the lower half, the uppermost very weak on upper whorls, twice their own width apart; on lower whorls there are traces of two extra equidistant spirals above these. Axial lamellae very fine and dense, exactly as in *laevifoliata*, but over-riding the spirals much more prominently. A strong extra spiral ridge arises from suture on base, as in *laevifoliata*, but stronger; below this smooth, but indications of 3 weak spirals as in *laevifoliata*. Aperture typical, outer lip much less crenulated than in the other two species.

Height, 4.2 mm.; width, 1.6 mm.

Locality—75 fathoms, North Cape.

Type in Finlay collection.

In its large strongly costate embryo this species resembles *alacer*, *laevifoliata* having a minute apex, finely and faintly costate. *Alacer*, however, has much coarser sculpture, especially on upper whorls. Both species have very much stronger spiral ridges and keeled whorls than *tertia*.

Murdochella superlata n. sp. (Fig. 31).

Shell small, distinctly clathrate, with an exaggerated basal keel. Embryo tiny (same size as in *laevifoliata*), last whorl with fine numerous axial riblets, ending in a prominent thin-edged varix. Adult whorls about 7½, narrow and very convex, with very deep sutures Two prominent spiral keels per whorl, with faint indications of a weak thread above, between, and below them; shoulder wide, convex, and practically smooth except for axials. Thirteen lamellar axials per whorl, many times their width apart, sinuous, antecurrent at suture above, crenulated by the spirals but not nodulous, the two enclosing a series of oblong pits. A tiny thread margins suture above; this runs out on base as a very sharp high and prominent ridge, cutting off the axials and enclosing a smooth concave space; at the junction of outer and basal lips it juts out as a prominent hollow point, curved to the right. Aperture subcircular, peristome incomplete, outer lip bordered by a thin widely fringed lamella, but no varix; pillar concave.

Height, 4.4 mm.; width, 1.3 mm.

Locality—75 fathoms, North Cape.

Type in Finlay collection.

A most extreme form of the genus. The exaggerated basal keel recalls the Rissoid genus *Promerelina* Powell and the Liotid one *Conjectura* Finlay, but the apical and other shell characters are quite different and show a close affinity to *laevifoliata*. Apart from the stronger basal keel, *superlata* differs from the other species of the genus in having far fewer axials and spirals, and differently shaped whorls; the apex is almost exactly as in the genotype.

Murdochella alacer Finlay.

This species was described (*Trans. N.Z. Inst.*, vol. 57, p. 402, Fig. 41, 1926) from 40 fathoms, Cuvier Island. I can also record it from 25 fathoms, Hen and Chickens; at each locality *laevifoliata* occurs with it. The latter species I also have from 60 fathoms, Poor Knights; 12 fathoms, Doubtless Bay; and 50 fathoms, Snares Island.

Key to the New Zealand species of *MURDOCHELLA*.

Protoconch small, with weak axials; sculpture dense; whorls keeled by strong spirals	*laevifoliata*.
Protoconch large, with strong axials; sculpture dense; whorls flatly convex; weak spirals	*tertia*.
Protoconch large, with strong axials; sculpture coarser, whorls keeled by strong spirals	*alacer*.
Protoconch small, with moderate axials; distantly clathrate; whorls bicarinate-convex, a very strong basal ridge	*superlata*.

Austromitra planatella n. sp. (Fig. 18).

Shell of moderate size for the genus, rather stout. Embryo of 1½ whorls, smooth and polished. Five adult whorls, slightly shouldered above upper third, faintly convex below, body whorl rather inflated. About 16 axials per whorl, not prominent, 3-4 times their width apart, very faintly nodulous on shoulder, crossing whorls from suture to suture, but entirely vanishing on base. Spirals almost obsolete, about two just below suture and 2-3 on angle, periphery practically smooth, base with numerous weakly indicated cords with linear interstices. Aperture capacious, outer lip thin and sharp. Pillar sloping to left, but not much twisted, with four plaits, the upmost stronger than and rather widely separated from the rest.

Height, 10.8 mm.; width, 4.5 mm.

Locality—38 fathoms, off Cuvier Id.

Type in Finlay collection.

This seems very close to the true Pliocene *Turricula planata* Hutton (*Trans. N.Z. Inst.*, vol. 17, p. 315, Pl. 18, Fig. 3, May, 1885) from "Wanganui," and is apparently its Recent representative; it is smaller and seems to have a more rapidly contracted beak and more numerous axials.

Austromitra lawsi n. sp. (Fig. 17).

Shell rather large for the genus, considerably resembling *Uromitra* Conrad in shape. Protoconch of less than 1½ turns, smooth and polished. Six adult whorls, well shouldered at about the upper

quarter, shoulder slightly concave, slightly convex below. Axials 13-14 per whorl, more numerous and sub-obsolete on last quarter turn, about own width apart, strong and prominent from suture to suture, vanishing on base. An obscure swelling margins upper suture, shoulder smooth, 7-8 spiral cords from angle to lower suture, not conspicuous, interstices wider, similar sculpture over whole body whorl, 14 spirals down to neck of canal, then a wider one just above first plait, then a considerably stronger one continuous with first plait, then 4-6 similar gradually weakening cords on neck of canal. Body whorl rather suddenly contracted leaving an excavated space between suture and first plait; canal rather long, well twisted. Aperture narrow, contracted suddenly to canal. Outer lip smooth inside. Pillar with four plaits, the upmost strong and sub-horizontal, the next two weaker and more oblique, the lowest very weak and often practically obsolete.

Height, 12 mm.; width, 4.6 mm.

Locality—50 fathoms, 10 miles E.N.E. of Otago Heads, several shells, dredged by M. Young. Also collected by C. R. Laws, for whom the species is named.

Type in Finlay collection.

This may be the Recent representative of the Pliocene *Turricula marginata* Hutton (*l.c.*; Pl. 18, Fig. 4), but is considerably larger and still has the axials prominent on body whorl. I have no specimens of *marginata* for accurate comparison. *Lawsi* is one of the largest and finest of our Austromitras.

Aeneator otagoensis n. sp.

Very close to *A. marshalli* (Murdoch) (*Trans. N.Z. Inst.*, vol. 55, p. 159, 1924), the genotype, from the Upper Pliocene of Castlecliff, and probably descended from it. Easily distinguished by fewer and stouter axials, 13 per whorl just before they die out, instead of about 18; interstices equal to or wider than ribs instead of narrower or sublinear. Spirals somewhat finer, less raised than in *marshalli*. Spire taller, considerably higher than aperture instead of subequal to it. Pillar considerably thicker.

Height, 55 mm.; of spire, 23 mm.; width, 24 mm.

Locality—22 fathoms, trawled between Otago Heads and Waikouwaiti, type and one other. Also two shells from 60 fathoms off Otago Heads, and one worn cast up shell, Taieri Beach.

Type in Finlay collection.

Perhaps all the Recent records of *marshalli* refer to this species.

Radulphus necopinatus n. sp.

Near *Cyllene lactea* Ad. and Ang., but broader and shorter; the spire is lower and the shoulder short, so that the whorls are medially sub-keeled; main spiral grooves fewer. Colour brownish, irregularly maculated with large white blotches on periphery, but shell is worn and does not show true colour. Apical whorls two, mamillate, smooth. Whorls with dense inconspicuous spiral grooving, the grooves with very faint punctures; more distinct on last whorl, eight of the linear grooves at regular distant intervals being more impressed and darker

coloured. There are very faint traces of coarse peripheral nodules on penultimate whorl alone, about 10 per whorl. Almost the whole surface in the unique type is covered with a secondary pitting of short linear punctures, irregularly disposed and directed, probably due to a bryozoan. Fasciole strong but short. Aperture rather small, outer lip thick but fairly sharp, inner lip rather callous, a pad on parietal wall and another at base of pillar encroaching on fasciole. Pillar excavated, with a *Phos*-like groove below. Canal rather wide, directed to left and notched backwards.

Height, 15.5 mm.; width, 9.5 mm.

Locality—Cape Maria van Diemen, one specimen.

Type in Finlay collection.

This is the first recorded member of this genus from New Zealand, and comes rather as a surprise. For the genus *Radulphus,* see Iredale *Proc. Linn. Soc. N.S.W.*, vol. 49, pt. 3, p. 270, 1924; the present species is much nearer to *lactea* than to *royanus* Iredale.

Murexsul mariae n. sp.

Like the Pliocene *espinosus* (Hutton), but much shorter and smaller, and relatively wider. Very squat and small for the genus, whorls inflated, regularly convex. Axials 12-13 per whorl, rounded and regular, a little less than their own width apart, hardly any further apart on body whorl. No spines. Spirals less raised than in *espinosus* and canal much shorter—only half as long. Three prominent ribs on neck of canal better indicated. Otherwise like the Pliocene shell.

Height 17 mm.; of spire and aperture, 7.5 mm.; width, 9 mm.

Locality—Cape Maria van Diemen, on the beach, type and ten others, quite constant; collected by lighthouse-keeper. One fresh specimen, possibly this species, but taller and more like *espinosus* except for canal, from Mt. Maunganui.

Type in Finlay collection.

Axymene teres n. sp. (Figs. 1, 2).

Shell small, short, stout. Embryo worn, but apparently ending in a keel. Whorls strongly keeled a little below middle, shoulder wide, steep, slightly concave, vertical below keel. Body whorl with shoulder and base steeply sloping away from a narrow sub-vertical periphery. The two angulations of this periphery are the only spiral sculpture, no threads except for one strong oblique ridge on neck of canal (typical of *Axymene*), and a faint indication of a second one above. Axials 7 per whorl, practically continuous from whorl to whorl, dying away on shoulder and not reaching suture, strong, projecting, and sharply angled on periphery (4-5 times own width apart), suddenly ceasing at lower angle, base not even undulated by them. Aperture and canal typical of the genus.

Height, 6 mm.; width, 3.3 mm.

Locality—50 fathoms, off Otago Heads.

Type in Finlay collection.

Closely resembles *waipipicola* (Webster) in habit, but shorter and stouter.

Zeatrophon pulcherrimus n. sp. (Figs. 8, 9, 12).

Shell small, lamellose, fenestrate. Protoconch typical, of three polygyrate and conic, rather glassy, tiny convex whorls, the tip forming a very minute button, ending abruptly in a sinusigerid curve, without a varix. Adult whorls about $5\frac{1}{2}$, sharply keeled just above middle, shoulder slope gentle, steeply sloping inwards below keel; body whorl subquadrate, sloping in from periphery to a second ill-defined very blunt angulation, then quickly cut in on base to a moderately long slender canal. Axials 14-15 per whorl, very narrow and sharply raised, doubly lamellose, reaching from suture to suture and on to inception of canal, antecurrent on shoulder, 3-4 times their width apart. Two prominent spiral ridges (equal to axials in width and height) on spire whorls, the peripheral one stronger, the other midway between it and suture, 2 more equidistant and just as strong emerge on base, with one slightly weaker between them, several lower but slightly coarser spirals thence down to tip of canal, 3 rather more prominent; shoulder with 3-6 much fainter spirals, appearing almost smooth, similar fine spirals between the main ones. Surface of shell cut up by this sculpture into transversely oblong pits, their bottoms concave and of a waxen sheen; intersections of axials and spirals (especially on periphery) raised into prickly but not high tubercles. Aperture and canal exactly as in *ambiguus*, but of course much smaller. Colour whitish, with a reddish-brown peripheral band, lower part of canal stained a lighter shade of same colour.

Height, 11.5 mm.; of spire, 5.5 mm.; width, 5 mm. (type). Larger broken shells reach 15 mm. height and 7.5 mm. width.

Locality—60 fathoms, off Otago Heads, type, not uncommon; also 38 fathoms, Cuvier Id., several small specimens (Fig. 12).

Type in Finlay collection.

Of the *bonneti* style, but quite distinct from that species in smaller size, lower and sharper keel, and less tabulated whorls, the two main spirals being on lower half of whorl instead of median, coarser and fewer axials, etc. The Cuvier Island shells are all juvenile, and may show differences when adult, but cannot be separated from Otago Heads shells of equal size. From the young of *ambiguus* these differ in finer ornament, straighter canal, and presence of three distinct cords on neck of canal.

Zeatrophon caudatinus n. sp. (Fig. 7).

At first sight differing widely from *pulcherrima*, but probably related, and derived from it by suppession of the main spirals, and reduction of the axials. The latter number 11 per whorl, considerably stouter and less lamellar than in *pulcherrima*, about $1\frac{1}{2}$ times their width apart, less antecurrent on suture. Spirals same in arrangement, but differing in relative strength; the main two on spire whorls are lower down (on lower third instead of half); all the main spirals are much lower and more cord-like, the interstitial ribs approximating to them in prominence, neck of canal with much coarser and closer cords, shoulder especially with much stronger sculpture, having three quite prominent cords. Surface not cut up

into pits, and intersections merely bluntly tubercular on periphery; all ribs with a rasp-like appearance, due to dense but much coarser lamellation than in *pulcherrimus.* Shell more slender, and body whorl with a blunt sub-angle instead of quadrate.

Height, 12.5 mm.; of spire, 6 mm.; width, 5.5 mm.

Locality—Hauraki Gulf, depth uncertain.

Type in Finlay collection.

This is very like Quoy and Gaimard's figure of *Fusus caudatus,* but is only one third the size. It therefore looks as though *caudatus* does not belong to this group (as I suggested in *Trans. N.Z. Inst.,* vol. 57, p. 413, 1926), unless it is a specially large member of it. So this species still remains a puzzle.

Zeatrophon tmetus n. sp. (Figs. 5, 10).

1924. *Xymene robustus* Finlay, *partim; Trans. N.Z. Inst.,* vol. 55, p. 520, pl. 52, Fig. 4b only.

Apex as described for *pulcherrima,* but not quite so tall, of about 2½ whorls. Adult whorls about 7, with a prominent, narrowly convex, not angled, submedian keel. Axials 11-13 per whorl, straight, extending from suture to suture, and on to neck of canal, strongly bluntly tubercular on periphery. Spirals 6 per whorl, the topmost one stout and margining suture below, the next two on shoulder, a little weaker, nearly own width apart, the next two stronger again, on periphery, very close together, only a linear groove between, then a wide excavated space equal to these two ribs, finally one more spiral margining lower suture. On body whorl this sculpture is continued, the sutural rib emerging as a strong cord equal to the two peripheral spirals put together, then another strong cord separated by another deep groove, half as wide as the upper one, then close spirals and furrows of diminishing strength and width down to fasciole. Dense lamellation as in *caudatinus,* but spirals not so rasp-like. Canal shorter than in *pulcherrimus* and *caudatinus,* and fasciole stronger, giving a more *Axymene*-like appearance. Aperture otherwise as in those species, thickened when fully adult, and with a few strong short denticles within; the fasciole is then rather prominent, and encloses a distinct umbilical chink.

Height, 16.5 mm; of spire, 9 mm.; width, 7 mm.

Locality—Stewart Island in a few fathoms (type and one juvenile); also two fully adult but worn shells on the beach at Otago Heads; one of these is the specimen figured by me as the paratype of my *Xymene robustus.* By taking the figure 4a as type of that species instead of 4b, I unwittingly made my species a synonym of *Axymene pumila* (Suter), as I have already explained (*Trans. N.Z. Inst.,* vol. 57, p. 422, 1926).

Type in Finlay collection.

This species is very close to and evidently the Recent representative of the Castlecliffian *Trophon huttoni* Murdoch (*Trans. N.Z. Inst.,* vol. 32, p. 221, 1900), but is more robust, with stronger knobs on periphery, which press the peripheral groove further down till

it almost margins suture. The character of the apex on these Recent shells justifies my tentative reference of *huttoni* to *Zeatrophon* instead of to *Axymene* (*l.c.*, vol. 57, pp. 424 and 425, 1926).

Bonellitia superstes n. sp (Fig. 16).

Shell close to, and evidently descended from, *B. lacunosa* (Hutton) (*Trans. N.Z. Inst.*, vol. 17, p. 320, 1885), described from the Nukumaruan Petane beds. Apex exactly the same, of 1¼ smooth shining whorls, the tip not globular, distinctly inrolled. Succeeding whorls regularly convex, with four strong but narrow spiral cords, 3-4 times their width apart, and a very fine thread on shoulder (distinct only on last whorl), 11 plus this thread on body whorl; no other spiral sculpture except for extremely faint and dense spiral scratches in the interstices, visible only under high magnification. Twelve axials per whorl, strongly backwardly oblique and reaching from suture almost to beak, narrow and strong, rather sharp, 3-4 times their width apart, raised into small tubercles at intersections with spirals. *B. lacunosa* has the whorls with a marked shoulder and sutural platform; 9 main spiral cords (thicker and blunter), no separate shoulder thread, but 3-4 fine irregularly spaced threads in the interstices between the ribs, and still finer threadlets on the ribs themselves, the shoulder bearing numerous threadlets; 16 thicker and blunter axials per whorl, 2-3 times their width apart, the intersections between spirals and axials considerably more gemmate. Details of aperture exactly as in *lacunosa*, except that topmost pillar plait is less projecting and further separated from lower two, the groove between being quite deep.

Height, 7 mm.; width, 4.5 mm.

Locality—25 fathoms, off Hen and Chickens, Hauraki Gulf.

Type in Finlay collection.

The range of this line is now extended in New Zealand from the Eocene (*B. hampdenensis* M and M., from Hampden) to Recent—a parallel case to that of *Inglisella*.

Inglisella (Anapepta) septentrionalis n. subgen. et sp. (Fig. 14).

Shell small, rudely sculptured, rather inflated, with disproportionate aperture. Embryo paucispiral, loosely wound, smooth and shining, tip globose. Three adult whorls, irregularly convex, with a steeply sloping concave shoulder. Two submedian narrow spiral cords marking low angulations, two more exactly similar on body whorl, with a further two extremely faintly indicated on base; spirals equidistant, many times their width apart, the wide shoulder and the interstices perfectly smooth and of a chalky appearance. Eight rude, knob-like axials per whorl, twice their width apart, strong only on periphery (the two upmost spirals), dying away rapidly on shoulder and base. Aperture large, the outer lip widely curved outwards (smooth within except for indications of the outer spirals) and downwards, the basal lip projecting to the left past the pillar, which twists sharply round to meet it in a prominent open spout.

Two prominent, median, tooth-like plaits on the pillar, well inside the aperture, not reaching the border of the inner lip.

Height, 5 mm.; width, 2.8 mm.

Locality—75 fathoms, North Cape.

Type in Finlay collection.

This is the only Recent species of *Inglisella* Finlay (founded on the Miocene *Ptychatractus pukeuriensis* Suter) yet described. It is very close to the Eocene *Admete anomala* M. and M. (*Trans. N.Z. Inst.*, vol. 52, p. 132, Pl. 6, Fig. 6, June 10, 1920) described from Hampden, showing how long this line has persisted in New Zealand. *I. anomala* has a higher spire, more and irregular spirals, and thicker axials, but its ancestral relationship to *septentrionalis* can hardly be doubted.

For the *anomala—septentrionalis* group I propose the subgeneric name *Anapepta* nov., naming the Eocene species as type. From typical *Inglisella* these shells differ chiefly in the formation of the aperture, which is not subtriangular and pointed anteriorly, but open and well rounded, curving basally into a channel well flexed to the left; the pillar is not straight and the plaits are stronger; the shells themselves are wider and shorter and have fewer whorls. An absolutely congeneric Australian Tertiary species is *Cancellaria etheridgei* Johnston *vide* Tate, *Trans. Roy. Soc. S.A.*, vol. 11, 157; Pl. 9, Fig. 6, 1889), and, judging from Tate's figures (*l.c.* Pl. 10, Fig. 8; Pl. 9, Fig. 7) his *micra* and *caperata* also belong here. On the other hand, from the Janjukian of Spring Creek I have a true *Inglisella*, apparently aff. *capillata* Tate, and *turriculata* Tate (*l.c.* Pl. 10, Fig. 14) also seems to be typical.

Iredale (*Rec. Austr. Mus.* vol. 14, No. 4, p. 265, 1925) has dealt with some of the small Australian Cancellarids, proposing two new genera, *Microsveltia* and *Pepta*, but seems to have fallen into a number of errors. His genus *Pepta*, proposed for the Recent *Admete stricta* Hedley, is a good one, and I have new Tertiary members from the Janjukian of Table Cape and Spring Creek; it is very similar in general shape and triangular aperture to *Inglisella*, but the pillar bears only one plait which merges into a callus over the umbilical region; Iredale and Hedley compared the Recent species with *turriculata* Tate, but this seems to be a true *Inglisella*. Iredale's genus *Microsveltia*, however, seems to me an absolute synonym of my prior *Inglisella*; it has the same shaped whorls triangular and pointed aperture, straight pillar, and two plaits. The Recent genotype, *M. recessa* Iredale, was compared with the Recent *Cancellaria exigua* Smith, with one plait (and thus probably a *Pepta*) and the Tertiary *micra* Tate, which from the figure has all the characters of *Anapepta*, so that Iredale seems to have confused three groups. I agree with him that *scobina* Hedley is unrelated to these small mono- and biplicate Cancellarids.

Oamaruia deleta n. sp. (Fig. 20).

Shell almost certainly descended from the Miocene *Admete suteri* Marshall and Murdoch (*Trans. N.Z. Inst.*, vol. 52, p. 132, Pl. 6, Figs. 5, 5a, June 10, 1920), but with the sculpture becoming effaced. Apex

exactly the same, of about 1¼ whorls, loosely wound, the tip blunt and globose, not well marked off from succeeding whorls. These have two fairly strong median spiral keels, as in *suteri* (but much weaker and blunter), crossed by 12 (instead of 15-16) axial ridges (much sharper and narrower in *suteri*, and forming sharp tubercles at intersections with spirals), feeble and antecurrent on shoulder, strong and vertical below it. Nine distant narrow spirals on body whorl, as in *suteri*, but much weaker; axials vanishing on concavity of base. Aperture as in *suteri*, but the two upper pillar plaits more oblique, and the lowest a little stronger.

Height, 5 mm.; width, 3 mm. (juvenile).

Locality—60 fathoms, off Poor Knights, two juveniles.

Type in Finlay collection.

Although only two not fully grown shells are known to me, I give the species a name on account of the interest of its lineage; better specimens are sure to be found when more dredging is done in Hauraki Gulf.

The shell, embryonic, and apertural features of *Zeadmete* Finlay are so similar that it should probably be given only subgeneric rank under *Oamaruia*. The latter has a better developed anterior beak, a weaker basal fasciole, and stronger pillar plaits, besides much coarser reticulate sculpture in the type species (though the Australian species have fine ornament).

Microvoluta cuvierensis n. sp. (Figs. 19, 21).

Shell differing at sight from *M. biconica* (Murdoch and Suter) in its smooth appearance. Axials and spirals are almost obsolete, but there is generally a well marked peripheral groove on the body whorl; the strong nodules and spirals of *biconica* are absent. Shell more slender, with a leaner body whorl. Sutural band quite different, in *biconica* there is a stout cord margining suture with a wide concave shoulder below it; in *cuvierensis* there is a broad low band with merely a narrow groove below it.

Height, 6.5 mm.; width, 2.7 mm. (type of *biconica* is 5 × 2.8).

Locality—38 fathoms of Cuvier Id., type and numerous other specimens; also 50 fathoms, Snares Id., several shells.

Type in Finlay collection.

This is quite distinct from *biconica*, one specimen of which was also obtained from 38 fathoms, Cuvier Id. For comparison, specimens of *biconica* from 25 fathoms, Hen and Chicken Id. are here figured (Figs. 13, 15); I also have the latter species from 60 fathoms, off Poor Knights, and 50 fathoms, off Oamaru. Smith has recorded (*Brit. Antarct. "Terra Nova" Exped.*, 1910, vol. 2, No. 4, p. 85,, 1915) *biconica* from 11-20 fathoms near North Cape, while Powell (*Trans. N.Z. Inst.*, vol. 58, p. 296, 1927) has collected it from 23 fathoms, off Ahipara. Both species seem to occur at Castlecliff (Upper Pliocene).

Nucula rossiana n. sp.

The Rossian representative of the Forsterian *N. dunedinensis* Finlay (*Trans. N.Z. Inst.*, vol. 59, p. 262, Figs. 1, 2, 43, 44, 1928),

from Dunedin Harbour, differing in shape and details of sculpture. Whole shell more obliquely ovate, anterior end more produced and more narrowly convex, posterior end much shorter, regularly lightly convex, base much less flattened; beaks at posterior fourth. Shell less inflated. Concentric sculpture same, but radials obsolete except just at margins. Umbonal grooves and ridges almost absent, but just visible. Characteristic is the flat, tabular, tiny prodissoconch, somewhat as in *Lissarca* but less prominent.

Length, 2.5 mm.; height, 2 mm.; diameter, 1.2 mm.

Locality—Auckland Islands, in shell sand at Faith Harbour, 5 examples.

Type in Finlay collection.

Distinguished from a species of *Pronucula* which occurs at the same locality by the hinge and absence of radials.

Nucula certisinus n. sp.

Shell very similar to *N. dunedinensis* Finlay, and probably its Cookian representative. It differs only in more triangular shape, much coarser concentric sculpture (about 10 ribs on lower half of shell instead of about 15), and more prominent swollen umbos. All the specimens are a little worn and probably not quite adult; umbonal ridges and furrows cannot be seen.

Length, 1.8 mm.; height, 1.6 mm.

Locality—Doubtless Bay, North Auckland, dredged in 12 fathoms, one perfect specimen and a single valve.

Type in Finlay collection.

Nucula gallinacea n. sp.

Shell small, with the sculpture of *N. hartvigiana* Pf., but the shape and compression of *N. strangei* A.Ad. Very little inflated, appearing smooth and shining to the naked eye, but under a lens showing strong concentric scultpure, the ribs rather wider than in *hartvigiana*, but less raised, somewhat anastomosing; crossed by rather distinct radial striae, the whole effect being much as in *Limopsis zelandica* Hutton. Anterior end like that of *hartvigiana*, but more winged, the highest point of the wing being more than half whole length of wing from umbo, instead of one-third of length, as in *hartvigiana*. Posterior end characteristic, sharply angled and rather produced instead of short and flatly truncate as in *hartvigiana;* the little sinuation in the truncation which is so marked in the latter species is absent. Base more convex. Hinge and ligament pit much weaker, the teeth quite small. Other details, including crenulated margin, as in *hartvigiana*.

Length, 4 mm.; height, 3.2 mm.

Locality—25 fathoms, off Hen and Chickens, 4 examples.

Type in Finlay collection.

This is not a bathymetric form of *hartvigiana,* for a variety of that species occurs with it. Were this species drawn out a little more, it would approximate very closely in shape to *N. strangei*.

Hochstetteria meleagrina Bernard. (Figs. 25, 26, 27).

Several species seem to be masquerading under this name in New Zealand. Suter remarked (*Man. N.Z. Moll.* p. 859, 1913) that "This is one of the most variable species of the genus I know," but I think the variation would be substantially reduced if some of the valid forms were separated as species. The northern specimens differ at sight from the southern ones, and there is more than one even in the south.

From off Otago Heads in 50-60 fathoms two species were commonly obtained, one very flat and trapezoidal, the other more inflated and triangularly oval. In the absence of Bernard's original description and figure, it is difficult to know which of these is the true *meleagrina*, for Suter certainly included them both in his description. I have finally regarded the more inflated form as Bernard's species, being guided in this respect by the following considerations; (1) Except off Otago Heads, it is much the commoner form, the flat form being known to me from only one other locality, while inflated shells occur throughout New Zealand, (2) I have a specimen of it from Foveaux Strait, the type locality, but no flat form from there, (3) It is a smaller shell, and Bernard's dimensions of his type indicate a small rather convex shell, (4) Hedley's comparative references to *meleagrina* when describing his *Phillippiella hamiltoni* (*Austr. Antarct. Exped.*, ser. C, vol. 4, pt. 1, p. 21, Pl. 1, Figs. 8, 9, 10, 11, 1926) agree better with this form than with the flat one.

If I have erred in this identification, my *pinctada* n. sp., described below, will be a synonym of *meleagrina*, and what I now figure as *meleagrina* will need a new name. The specific name is no help in identification, some species of *Pinctada* (= *Meleagrina*) being more like the convex form, others like the flat one.

If I am correct, typical *meleagrina* is restricted to the Forsterian and Rossian provinces, and is fairly constant in shape. It is roughly triangularly circular or oval, the basal margin lightly convex, the posterior truncation straight or lightly convex, the dorsal margin straight, and the anterior side strongly concave below the beak, then strongly convex. Shell not elongate, about as wide as high. Beaks anterior, but the convexity of the front margin extending some way beyond them. Shell rather convex. Surface moderately polished with very low but distinct irregular raised radial ridges. Epidermis not seen on any specimens.

Dimensions of largest specimen (Fig. 25): Height, 4.5 mm.; breadth, 4 mm.; width (1 valve), 1 mm.

Localities—35 fathoms, Stewart Id. (type); 60 fathoms, Otago Heads, not uncommon (figured specimens); 50 fathoms, Snares Id. (in company with *modiolus* Suter, which is there much the commoner).

Type in Mus. Hist. Nat. Paris; figured shells in Finlay collection.

Hochstetteria pinctada n. sp. (Figs. 22, 23, 24).

Also pretty constant in shape, sub-trapezoidal, with almost straight sides, basal margin flatly convex, posterior truncation being long and straight (extending nearly whole length of shell, instead of restricted to a medial portion), dorsal margin long and straight, and the anterior side also practically straight, only a little excavated below beaks. Shell elongate and strongly oblique, much longer than wide. Beaks the most anterior part of the whole shell, projecting well beyond rest of anterior margin. Shell flattish, internal cavity small. Surface highly polished, usually without raised ridges, but with obscure darker patches indicating radiate riblets. Epidermis rather persistent, thin, horny-cuticular, and polished, well prolonged beyond margins, totally without imbricating lamellae, spines, or sculpture of any kind. Prodissoconch larger and much less tabular, not so much projecting.

Height, 5.6 mm.; breadth, 4.2 mm.; thickness (1 valve), 0.7 mm.

Locality—50 fathoms, 10 miles E.N.E. of Otago Heads, type and numerous other specimens; also 50 fathoms off Oamaru.

Type in Finlay collection.

This has a surprising miniature resemblance to the pearl oyster, *Pinctada margaritifera.*

Hochstetteria munita n. sp. (Figs. 28, 29, 30).

Very similar to *meleagrina,* and probably its northern littoral representative. In shape somewhat intermediate between that species and *pinctada,* elongate like the latter, but convex like the former; sides not subparallel as in *pinctada,* and relatively narrower than that species, beaks more anterior than *meleagrina,* but not totally so. Prodissoconch as in *meleagrina,* but not quite so prominent. Epidermis persistent, but quite different from *pinctada;* developed into numerous radial ridges with long spines and concentric lamellae, like the ornament of *Cosa,* but existing only in the epidermis, vanishing when this is rubbed off, leaving a moderately polished surface with obscure radial ridges like *meleagrina.*

Height, 4.2 mm.; breadth, 3.2 mm.; thickness (1 valve), 1 mm.

Locality—Tryphena, Great Barrier Id., under small stones in direct contact with sand, half to low tide, common; collected by A. W. B. Powell. Also Lyall Bay, in shell sand, common (Fig. 28).

Type in Finlay collection.

Plurigens n. gen.

Type: *P. phenax* n. sp.

A genus of the Veneridae, combining features of several groups. It has a superficial appearance to both *Tawera* Marwick and *Dosinula* Finlay; larger than the former, more *Chione*-like than the latter. A minute anterior lateral denticle present. Sculpture very curious, initially of thin regular raised lamellae, exactly as in *Dosinula,* later of heavy broad sulcations, somewhat anastomising at the sides and cut off by the margins of the shell. Other characters given under the specific description.

I would also include here *Tawera* (?) *carri* Marwick *Trans. N.Z. Inst.*, vol. 57, p. 617, Figs. 164, 165, 1927) from Neilson's Quarry, Taranaki (Taranakian).

Plurigens phenax n. gen. et sp. (Figs. 3, 4, 11).

Shell moderately large, elongate-oval when half grown, circularly-oval when adult, inflated, beaks prominent, at anterior third when adult, between this and median when younger. All margins regularly curved in the adult (the basal curve a little flatter than the others), the posterior curve slightly interrupted by the end of the escutcheon, the anterior curve flattening at the lunule. In young shells the dorsal margins are much lower and flattened and the beaks much less conspicuous. Lunule broadly lanceolate, shallow, bounded by an incised line, strongly concentrically ridged, escutcheon rather narrow, deep, bounded by a sharp strong ridge, a little wider in left valve, almost smooth. Initial sculpture of raised sharp thin concentric lamellae, about 20 per cm., later sculpture of heavy thick concentric ridges, rising sharply and even concave on the beak side, sloping gently and then more steeply on the margin side; they are at first decidedly not parallel to margin, which cuts across them at the sides, leaving the truncated ends abutting on the following ridge; as senility is reached the ridges more closely follow the margin; the ridges are inclined to anastomose, especially at the sides; interstices about half width of ridges at first, but gradually becoming narrower. Fine radial striation covers the whole surface, developing near margin almost into definite radial ribs with linear interstices. Hinge-plate strong and broad, with sinuate margin; right valve with the cardinals subequal in length, the anterior at 45 degrees, thin and sharp, the median vertical, very stout, grooved posteriorly, the posterior at 35 degrees, moderately stout, medially grooved, a very faint indentation corresponding to an anterior lateral; left valve with the posterior cardinal longer, at about 30 degrees, thin and ridge-like, median at about 60 degrees, stout and deeply grooved, anterior subvertical, sharp, moderately stout, a distinct low bulge where the anterior lateral would be. Margins of valve, including lunule, finely crenulate. Nymphs strong and wide. Muscular impressions large and deep, especially at and under anterior end of hinge. Pallial sinus rather large, tongue-shaped, steeply ascending, pointing at middle of opposite muscle scar, top rounded, meeting pallial sinus at an angle of about 50 degrees.

Length, 50 mm.; height, 49.5 mm.; thickness (1 valve), 15 mm. (type). Length, 29 mm.; height, 24 mm.; thickness (1 valve), 8 mm. (half-grown shell).

Locality—60 fathoms, off Otago Heads, 3 adults, 5 intermediate shells, and some uncertain juvenile specimens.

Type in Finlay collection.

In its initial sculpture this species cannot be separated from *Dosinula zelandica*, though the adult shape and beak inflation is more like *crebra;* juveniles under a certain size cannot be separated from *zelandica.* In its later sculpture the species is just as like

Tawera marionae Finlay, but it differs from that species in being more oval, due to the straighter dorsal margins in the young shell. The ligament is very short and much incurved, so that a very high and prominent escutcheon is formed, outside of which there is hardly any smooth area as in *marionae*. The margin is more finely crenulate The bulge in the hinge line caused by the pedal retractor enhances the resemblance to *Dosinula*, but the hinge seems to be nearer that of *Tawera*.

The area with lamellate sculpture may be small or quite considerable; the type specimen has only about 6 mm. of it, while the figured paratype (Fig. 4) has about 15 mm. The deceptive resemblance thus given to *Dosinula* is really remarkable, and if Suter handled specimens of this form when he recorded *C. subsulcata* Suter as Recent, his reference of the species to *Cytherea* is pardonable. (In the Canterbury Museum there is one left valve of *phenax* from East of Jones Head, labelled "*Cytherea subsulcata*," probably by Suter). Perhaps this initial sculpture of lamellae is a reversion to a more primitive ancestral type, as the two earliest known species of *Tawera* from New Zealand (*pukeuriensis* and *waiauensis* Marwick)* both have lamellate sculpture.

The possibility that *phenax* is a hybrid between *Dosinula zelandica* and *Tawera marionae*, which both occur plentifully with it, has not been overlooked, but the three large adult shells of *phenax* are quite constant in their peculiar features, a Tertiary ancestor is known, and especially the pallial sinus is quite different from either of the other two species, which have it short and sharply angled, not ascending. The pallial sinus in the figure of the type (Fig. 11) has been disfigured by some parasitic animal, and appears much too wide.

Notes on Recent Papers dealing with the Mollusca of New Zealand.

By H. J. Finlay, D.Sc.

[*Issued separately, 23rd August, 1930.*]

Plate 46.

The following notes deal with nomenclatural confusion or erroneous location of species in certain papers which have lately appeared on our mollusca. The title and reference to each paper is given, and the points in it dealt with in order of their occurrence, the page being quoted to facilitate reference.

(1.) "The Geology and Palaeontology of the Lower Waihao Basin, South Canterbury, New Zealand." By R. S. Allan. (*Trans. N.Z. Inst.,* vol. 57, pp. 265-309; issued separately, Dec. 7, 1926).

In this paper Dr. Allan gives faunal lists of mollusca from the Waihao Downs, McCulloughs Bridge, and Mt. Harris. In the original form in which the paper was presented the generic locations current at the time were used. Since Dr. Allan had to depart for England, it was arranged that the proofs were to be sent to me for correction, and as my "Further Commentary" was to appear simultaneously I corrected the lists to agree with the changes in nomenclature proposed in that paper. When I returned the proofs I mentioned this to the Editor, and stressed the point that Dr. Allan's paper must on this account appear after mine. Somehow or other this was overlooked, and as a result we have long lists of mollusca with new generic names appearing before those genera were formally introduced. Such a piece of carelessness might have had much more serious results than it has, for fortunately nearly all the new names introduced in these lists are a sort of *nomina nuda* and can depend for their valid introduction only on the "Commentary." For example, the list name "*Zaclys* (*Miopila*) *tricincta* (Marshall)" does not indicate whether the new names *Zaclys* and *Miopila* apply to *Epitonium tricinctum* Marshall, 1918, or to *Cerithiella tricincta* Marshall, 1919, while "*Zexilia waihaoensis* (Suter)" might apply to a form of *Ampullina, Exilia, Pecten,* or *Rapana,* Suter having given this specific name to a species described under each of these generic names from these same beds. As the lists are arranged in alphabetical order, no help is obtained from the relative position of the names. Consequently, unless further information is supplied, one must regard the quotation of a new generic name with a mere species name and author's name in brackets as indeterminable, and practically a *genus caelebs.*

The complete list of new names inadvertently introduced in this paper is as follows:—

Marshallena, with *serotina* (Suter) (p. 289), *formosa* (Allan), *neozelanica* (Suter), and *spiralis* (Allan) (p. 291).
Spirocolpus, with *waihaoensis* (Marwick) (p. 289).
Waimatea, with *inconspicua* (Hutt.) (pp. 289, 291), *apicicostata* (Suter), and *opima* Allan MS. (p. 291).
Notoseila, with *attenuissima* (M. & M.) (p. 291).
Proximitra, with *parki* (Allan) and *plicatellum* (M. & M.) (p. 291).
Zaclys (*Miopila*), with *tricincta* (Marshall) (p. 291).
Zeacolpus, with n. sp. (p. 291).
Zexilia, with *crassicostata* (Suter) and *waihaoensis* (Suter) (p. 291).
Maoricolpus, with *cavershamensis* (Harris) (p. 304).
Stiracolpus, with n. sp. (p. 304).
Venustas, with *fragilis* (Finlay) (p. 304).
Xymenella, with *lepida* (Suter) (p. 304).
Zeacrypta, with *monoxyla* (Lesson) (p. 304).
Coluzea, with *dentata* (Hutton) (p. 304).

All but two of these premature names can be disregarded; *Marshallena* and *Coluzea,* however, must be regarded as validly introduced on this occasion.

On p. 291, footnote, Allan notes that *Marshallena neozelanica* (Sut.) is *Daphnella neozelanica* Suter and equals *Belophos incertus* Marshall. That is sufficient to validate the name, and this species becomes the monotype of *Marshallena* Allan; fortunately I designated the same species as type when the later proposition appeared in the "Commentary," 122 pages later.

The other case has not such a fortunate outcome. On p. 304 appears the line "*Coluzea dentata* (Hutton) (as *Fusus*)." This is again definite fixation of the generic name, so that *Fusus dentatus* Hutton becomes the monotype of *Coluzea* Allan, instead of the Recent *spiralis* A. Ad., for which I proposed the name 103 pages later. This, however, makes no difference in the conception of the genus.

One other alteration in this paper must be credited to Allan instead of to me. On p. 291, footnote, it is noted that "*Turbonilla hampdenensis* Finlay" is a new name for *T. antiqua* Marshall, preoccupied. The new specific name must, of course, be referred to Allan as author.

(2.) "Description of Two New Shells of Marine Gasteropod." By C. E. R. Bucknill. (*Trans. N.Z. Inst.*, vol. 58, pt. 3, pp. 311, 312; issued separately, Nov. 8, 1927).

Mayena multinodosa (p. 312). This seems to me better referable to *Fusitriton* Cossmann than to *Mayena.* It has every character of *retiolum* (Hedley) and *laudandus* Finlay except that the varices are regularly in line on opposite sides of the shell and are more strongly developed. But *Mayena* has not the varices in line either, and the other shell features agree well with *Triton cancellatus* Lk., the genotype, and the Californian *oregonense* (Redwood), which often shows varices almost in line on early whorls. Apart from the varices, *multinodosa* is well distinguished from *laudandus* by the character and

number of the spirals and I would regard it as a second Neozelanic species of *Fusitriton.*

(3.) " Some New Zealand Molluscs." By Marjorie K. Mestayer. (*Proc. Mal. Soc., Lond.,* vol. 17, pts. 5 and 6, pp. 185-190; Dec., 1927).

In this paper Miss Mestayer proposes six new specific names—every one of which is a synonym of a previously described species. Most of these had been named in my own " Further Commentary," published Dec. 23, 1926, so that a full year elapsed before these redundant names appeared; ample time to withdraw them from publication. Such work is not helpful to science; we have enough nomenclatural problems in New Zealand without adding to them in this fashion. The time and money expended on this paper could have been more profitably employed. The synonyms are as follows:—

Brookula rexensis Mestayer (p. 185) is based on exactly the same specimen which I had previously named *B. prognata* (*Trans. N.Z. Inst.,* vol. 57, p. 366; 1926).

Monodonta lugubris albina (p. 186) is a freak no more worth a name than an albino of any other species. I have seen red examples of *Zediloma digna* Finlay (= *nigerrima* auct.).

Triviella maoriensis (p. 186) is a perfect synonym of my *T. memorata* (*l.c.,* p. 396), from the same locality, Ahipara Bay.

Triviella gamma (p. 188) is not only a synonym but also a foreign shell. Miss Mestayer informed me that the specimens were given to her by Suter, who probably obtained them by exchange and mixed them up with local shells. The species is one of the common tropical forms, probably *pediculus* Linn.; at all events there are shells so named in the foreign collection of the Dominion Museum, which are identical in appearance and preservation.

Fusitriton futuristi (p. 189) cannot be separated as a species from my *F. laudandum* (*Trans. N.Z. Inst.,* vol. 57, p. 399; Pl. 20, Fig. 65; Dec. 23, 1926). My species was described from 40 fathoms off Otago Heads; Miss Mestayer's is from 50-60 fathoms off Cape Campbell, some 340 miles further north, and mine was stated to " differ in several respects from *F. futuristi,* the axials and spirals both being stronger, and the denticle weaker." The denticle is of no specific importance, and Miss Mestayer's figure shows sculpture equal in prominence to *laudandum.* It is difficult enough to distinguish *laudandum* from the Australian *retiolum* Hedley, without attempting to separate a second New Zealand species of this type, both being known from single specimens. As I have just noted, I regard *Mayena multinodosa* Bucknill as a second New Zealand species of *Fusitriton,* but it is of a different type in its variceal development.

Pecten (*Cyclopecten*) *hinemoa* (p. 190) is again proposed for the identical specimen which I had named *Cyclochlamys secundus* (*l.c.,* p. 453).

(4.) " Notes on New Zealand Mollusca." No. 4. By Marjorie K. Mestayer. (*Trans. N.Z. Inst.,* vol. 60, pt. 2, pp. 247-250; issued separately, Aug. 15, 1929).

The practice adopted in this paper of writing all specific names with capitals does not seem an improvement on the existing system;

besides being in direct contravention of Article 13 of the International Rules of Zoological Nomenclature.

Pallium kapitiensis, described in this paper (p. 249), is certainly a synonym of the common *Pecten convexus* Q. & G. Supposed differences in the ribbing and posterior ear are pointed out, but these are quite variable. It is impossible to distinguish two satisfactory forms of this species; the flatter shells usually have broad, low, radial ribs with sublinear interstices, while the very convex shells have generally more numerous thin and sharp radials with wider interspaces, but neither form is constant, and the sculpture may change from one type to the other on the same valve, following a rest period and inturning of the shell. All my Chatham Island valves are of the flat broadly ribbed type, but off Otago Heads in 60 fathoms occur numerous valves showing every gradation and interchange of the two types. The flatter valves are mostly like the Chatham shells, but merge gradually into extremely convex and inflated shells, with ribbing exactly like Miss Mestayer's type—which she states is rather flattened. Furthermore, exactly the same variation and intergrading of the two types is found in Tertiary ancestral forms, the Miocene *burnetti* Zittel, etc., being exactly comparable to *convexus* in this respect.

There are enough very distinct new species to describe in New Zealand without creating synonyms in this fashion.

(5.) "Tertiary and Recent Volutidae of New Zealand." By J. Marwick. (*Trans. N.Z. Inst.,* vol. 55, pp. 259-303; issued separately, March 13, 1926).

This fine monograph gives for the first time an adequate account of the New Zealand Volutidae. Although the classification adopted is in the main perfectly satisfactory, there are one or two minor points which I think might receive further attention. A large number of the species were described from my collection, which is fairly complete in the group except for some Pliocene species, and I have had occasion several times to go over critically several of Marwick's groupings. Therefore, with due deference to his opinion, as that of an expert who has given much study to the group, I suggest the following changes and occasionally re-groupings as being, in my opinion, more natural.

Genus *Mauia* (p. 271). This is a compact assemblage with the exception of *M. insignis* Marwick (p. 274), which is also widely sundered from the other (early Tertiary) members in age, being a Pliocene shell. It has much more prominent and numerous axial ribs, which extend from suture to basal fasciole, and a peculiarly ascending and channelled outer lip where it joins the parietal wall. It is difficult to say whether it is allied more closely to *Mauia* or to *Pachymelon.* My personal opinion is that *Mauia* became extinct soon after the development of increasing geronticism and size in its latest members, *curvispina* and *huttoni,* and that the deep anterior notch of *insignis* indicates either a throw-off from the *Alcithoe* line, or, more probably, an evolution from *Pachymelon.* Taking this view, I propose to separate *Mauia insignis* Marwick by naming it as type of a new genus *Mauithoe.*

With it I feel inclined to associate *Alcithoe parva* Marwick (p. 301), described from Kaawa Creek. *Alcithoe propearabicula* Bartrum and Powell (*Trans. N.Z. Inst.*, vol. 59, p. 148; Fig. 61; May 24, 1928) is, I feel sure, a synonym of this species, coming from the same locality, and the figures and descriptions agreeing in every detail. All the principal features of *Mauithoe* seem to be shown by this Waitotaran species, while *Alcithoe dilatata* Marwick (p. 301) is a species certainly congeneric with *parva*, and may also be located here. These two species seem to be descended from *Mauia* stock rather than on the *Alcithoe* line, and though shorter in the shell than *insignis* may be genetically associated with it at present.

Sub-genus *Pachymelon* (p. 281).—My conception of Marwick's genus *Waihaoia* and this subgenus differ a little from his. Specimens in my collection indicate that *Waihaoia* and *Teremelon* were barely distinct in Tahuian times (though abundantly so later), but that *Waihaoia* was earlier developed, being well established in Bortonian beds. In the Hutchinsonian, *Pachymelon* was just evolving from *Waihaoia*. After Marwick's account was written, I collected several more species of this group in the Clifden beds, and certain forms from beds 7 and 8 seem to indicate quite definitely the transition stages between *Waihaoia*, which is common in beds 4 and 6, and *Pachymelon*, which predominates in beds 7 and 8. Adult examples, for instance, from bed 8 show that my *Alcithoe regularis*, which Marwick referred to *Waihaoia*, is really a *Pachymelon*, growing much wider, thicker, heavier, and shorter in the spire than the juvenile type would lead one to suppose. Bearing this in mind, I would also refer *Waihaoia dyscrita* (Finlay) (p. 276) to *Pachymelon*, as a transitional form; no further specimens have been found.

Turning now to the species included by Marwick (p. 281) in *Pachymelon*, I note that the Recent *lutea* (Watson) (p. 282) has already been extracted from this association and made the monotype of *Palomelon* Finlay (*Trans. N.Z. Inst.*, vol. 57, p. 432; Dec. 23, 1926). Powell, in his list of our Recent Volutidae (*l.c.*, vol. 59, p. 364; Aug. 30, 1928), has overlooked this, also my reference of *Microvoluta biconica* (Murd. & Suter) to the Volutidae (*l.c.*, vol. 57, p. 410).

Waihaoia (*Pachymelon*) *waitakiensis* Marwick (p. 281) may also be removed from this neighbourhood; it is a *Spinomelon*, and a synonym of *S. benitens* (Finlay). I have a topotype from Wharekuri identical with *waitakiensis*, and this offers no separative characters from the smooth *benitens*, which is from beds not far above. This is the only one of Marwick's species with four plaits on the pillar, so I would amend his subgeneric diagnosis to read "Columella produced, generally with 5 folds, occasionally 6, never 4."

Waihaoia (*Pachymelon*) *renwicki* Marwick (*Trans. N.Z. Inst.*, vol. 58, p. 488, Fig. 147; Feb. 28, 1928), from Whenuataru Peninsula, Chatham Island Tertiaries, has also now to be added to the list of species.

Genera *Spinomelon* (p. 283) and *Metamelon* (p. 285).—Although the great mass of our Volutes have a secondary scaphelloid nucleus, *i.e.*, not originally shelly, and therefore roughened and variable in

form, only *Spinomelon* and *Metamelon* of all our groups have a sharp caricelloid apex, with a strong spike. Even apical fragments can be with certainty referred to these genera, and it becomes a matter of importance to distinguish between them when juvenile. Marwick has not made this clear, but it can be done with the smallest fragments, if the embryo is complete. The apex of *Metamelon* is always narrow and tall and followed by smooth spire whorls, sculpture developing later, if at all; that of *Spinomelon* is in a few aberrant forms somewhat like that of *Alcithoe*, globose and rounded with not much indication of a spike, but is typically strongly spiked and always considerably wider than that of *Metamelon*, shorter and larger, and followed by costate spire whorls, sculpture obsolete only occasionally on the last whorls; both genera agree in the roughened first volution and spike, and smooth second volution with 2-4 irregular thread-like keels.

As regards the species of *Spinomelon*, I have just noted that *Pachymelon waitakiensis* Marwick is a synonym of *benitens* (Finlay). *Alcithoe residua* Finlay (p. 301), as Marwick thought, shows much stronger affinity to *Spinomelon* than to *Alcithoe*; having seen some similar new species, I now refer it definitely to that genus as a somewhat aberrant line. One other addition is *Fulgoraria* (*Alcithoe*) *arabica* var. *turrita* Suter, which Marwick (p. 288) included as an early member of *Alcithoe*. I have some perfect apices from Blue Cliffs (the type locality) which show the characteristic sculpture and whorl shape of *turrita*, but have the spike and other embryonic features of *Spinomelon*. They are not *parki*, and answer only to Suter's species. It is easy, too, to see the natural affinity between *speighti* and *turrita* as shown by Marwick's figures (Pl. 64, Fig. 7 and Pl. 66, Fig. 8); *turrita* is a good species of *Spinomelon*, chiefly characterised by its high spire. This leaves the earliest *Alcithoe* as *wekaensis* Marwick (p. 288), which is by no means typical. I am inclined to think that some at least of the Alcithoes arose from *Spinomelon*.

Metamelon minima (p. 287).—The type is from Mt. Harris, not Otiake as given by Marwick. It is a curious form, but seems best placed here.

(6.) "Mollusca from Kaawa Creek Beds, West Coast, South of Waikato River." By J. A. Bartrum and A. W. B. Powell. (*Trans. N.Z. Inst.*, vol. 59, pt. 1, pp. 139-162; issued separately May 24, 1928).

In this paper several of the names proposed by me in the "Further Commentary" are rejected. In subsequent correspondence the authors have admitted that in some cases their reasons for rejection were insufficient, while in others I had not made myself clear enough in defining the groups (*e.g.*, *Zelandiella*, for the subsequent acceptance of which as a distinct genus see Powell, *Trans. N.Z. Inst.*, vol. 60, p. 93; 1929).

Some of the species described or recorded require comment, as follows:—

Spectamen cf. *egena* (p. 140).—"Finlay . . . ., anticipating distinctive radular characteristics, has introduced a new generic name *Antisolarium*." This is incorrect; reference to my original proposi-

tion (*Trans. N.Z. Inst.*, vol. 57, p. 359 and 360; Dec. 23, 1926) of *Antisolarium, Zeminolia, Zetela,* and *Conominolia* will show that these four groups were proposed on *shell characters.* It is sufficient to quote the following, which seems to me clear enough: "It is quite impossible, therefore, to forecast the radular features of the Neozelanic series, and as they disagree conchologically with Australian shells, I consider the correct course to pursue is to propose new names for the different groups met with in New Zealand, and wait until the animal characters are available to ascertain definitely their generic or subgeneric value." *Spectamen* is an impossible location for *egena,* for it has a different protoconch, shell formation, and aperture. A tiny inconspicuous embryo like that of *Antisolarium* and *Conominolia* is shown only by *Ethminolia* of the Australian groups, but this has the shell features and aperture of *Spectamen* (but of course a different radula, while the characteristic habit and aperture of *egena* are well shown in the figure given by Cossmann (*Ess. Pal. Comp.*, livr. 11; Pl. 8, Figs. 57, 58—as *zelandica* Hutt.). As I stated before, *Antisolarium* rather recalls *Solariella* in shell features, though it may be noted that Cossmann, dealing with all these forms, did not associate it with *Solariella,* but with *Conotrochus* Pilsbry (*l.c.*, p. 262), indicating a definite distinction even here. A large and bulbous embryo distinguishes the groups *Zeminolia* and *Zetela,* and the Australian groups *Spectamen* and *Minolia,* though in the two latter it is not so disproportionately developed. Of all the New Zealand groups *Zeminolia* is most like *Spectamen,* but has a still more open umbilicus, and larger embryo; the two forms are more distinct than are *Spectamen philippensis* and *Ethminolia probabilis,* which have quite different radulae, and I consider it misleading to group them together. In view of the complex relationships of these shells, and the unavailability of the radula in Tertiary forms and many Recent ones, I would lay it down as a fixed principle that no two Minolioids can be generically associated whose protoconchs do not exactly agree; whatever the radulae of the New Zealand species turn out to be when investigated, I would still separate them from the Australian series *on shell and embryonic differences alone.*

Turbo postulatus Bartrum (p. 141).—A detailed discussion of this shell and the interesting problems it raises is given in a separate paper in this volume.

Struthiolaria (p. 142).—Of the three new species proposed here, *arthritica* is a *Callusaria*—one of the last of the group—and *pseudovermis* is a *Pelicaria.*

In the "Further Commentary" (p. 391) I provided *Callusaria* for the four species included by Marwick (*Trans. N.Z. Inst.*, vol. 55, pp. 182-184; June 6, 1924) in his "*Struthiolaria callosa* group." I would now extend its limits, and class the following succession of species in *Callusaria*: *obesa* Hutton, *arthritica* Bartrum and Powell, *fortis* Marwick, *armata* Marwick, *callosa* Marwick, *spinifera* Marwick, *spinosa* Hector, and *tuberculata* Hutton. To my mind these form a compact assembly, agreeing in apex, but differing in shell and spine formation, and somewhat in aperture, from *Struthiolaria* s. str., under which I would range *papulosa* Martyn, *frazeri* Hector, *errata* Mar-

wick, *cingulata* Zittel, *illepida* Bart. and Powell, *cincta* Hutton, *praenuntia* Marwick, *calcar* Hutton, *subspinosa* Marwick, and *prior* Finlay.

Genus *Crypta* (p. 144).—" Finlay . . . ., apparently on the basis of anticipated differences in the radula of New Zealand shells from those of Crepidulids of other areas, creates a new genus *Maoricrypta.*" This again is a mis-reading of my account (*Trans. N.Z. Inst.*, vol. 57, p. 393; Dec. 23, 1926); I pointed out valid shell differences between *Maoricrypta* and *Crypta,* and these have since been substantiated by Marwick (*l.c.*, vol. 59, p. 918; March 25, 1929).

Xenophalium (p. 145).—In this paper and elsewhere Powell argues that *Xenogalea* Iredale is a synonym of *Xenophalium* Iredale, and classes all our species of *pyrum* affinity under the latter name. I disagree with this. *Xenogalea* is a compact association of species, and *hedleyi* Iredale and *royana* Iredale cannot be forced into it without destroying its unanimity. Powell later (*Trans. N.Z. Inst.*, vol. 59, p. 635; Nov. 23, 1928) writes that " Iredale in defining the first-mentioned genus stated that it was characterised by large size and open unarmed mouth. This latter feature is also common to most of the species of his second genus *Xenogalea,* leaving the larger size as the only distinguishing character. This feature alone is hardly sufficient justification for creating a new genus. . ." Everyone who has worked in Natural Science knows how difficult it is to define exactly in words the precise differences between convenient genera in large groups of similar forms. Iredale does not err on the side of verbosity, but his conceptions of genera seem very natural, and in the present case his separation of *hedleyi* from the common forms appears to me quite justified. Powell's own figures of *royana* (*l.c.*, Pl. 74, Figs. 11, 12) have a different look from all his figures of *Xenogalea,* though it is not easy to put the difference into words. But the characteristic style of nodulation, the high spire, the long body-whorl, not inflated anteriorly, and the straight hardly-wrinkled pillar, combined, as Iredale says, with large size and open unarmed mouth, sufficiently differentiate this species, *hedleyi* Iredale, and probably *wyvillei* Watson from true *Xenogalea.* I would suggest that there is at least as much difference between these two groups as between the species *harrisonae* Powell and *multisecta* Finlay, which Powell places in different genera.

Alcithoe propearabicula (p. 148).—I have already noted that I think this is a synonym of *Mauithoe parva* (Marwick, 1926), from the same locality.

Genus *Austrodrillia* (p. 150).—The reasons given for the merging of *Splendrillia* Hedley with the same writer's *Austrodrillia* are not very convincing, being merely May's reference, in a list of species, of *woodsi* (genotype of *Splendrillia*) to *Austrodrillia*—possibly inadvertently. *Austrodrillia* is easily distinguished from *Splendrillia* by its simple outer lip and sinus.

Semeloidea donaciformis (p. 158).—This new genus was compared by its authors to *Donax* and, more closely, to *Semele.* But it is evidently a member of the Erycinidae, allied to *Myllitella, Zemyllita, Rochefortula,* etc. This was my impression from the figures, and actual specimens I have since seen confirms it. Compare such a

species as *Bornia lioica* Dall (*Tert. Fauna Florida,* pt. 4; Pl. 25, Fig. 6) from the Caloosahatchie Pliocene, which is of the same style and shows similar sulcations.

(7.) "Tertiary Molluscan Fauna of Chatton, Southland." By J. Marwick. (*Trans. N.Z. Inst.,* vol. 59, pt. 4, pp. 903-934; issued separately, Mar. 25, 1929).

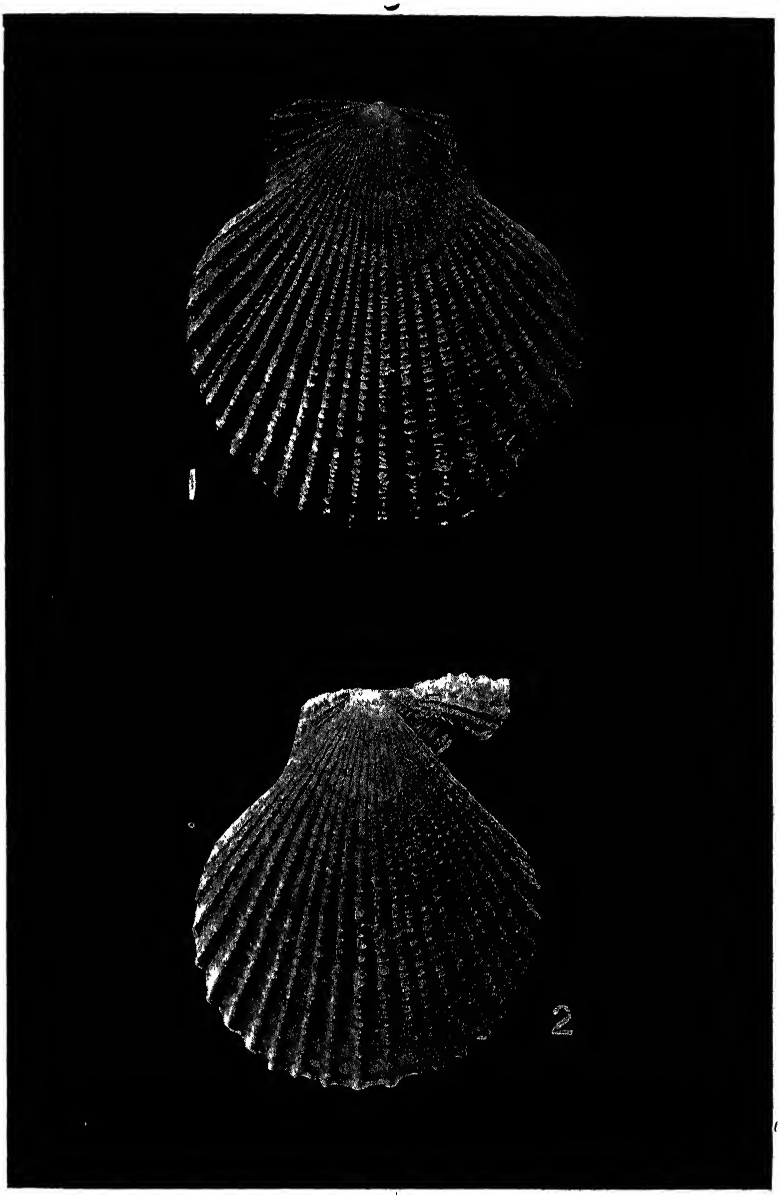
One or two of the species described in this paper call for comment.

Cyclopecten compitum (p. 909).—This is not a *Cyclopecten,* but a nepionic *Chlamys* with merely the beginning of the adult sculpture. No *Cyclopecten* has this irregular ornament, but every *Chlamys* starts off more or less in this fashion. Enough of the adult sculpture is developed to show that the species is of the *chathamensis* type, and is the same as that occurring commonly in the Wharekuri greensands. I have one half-grown shell from Chatton which corresponds at the umbo with *compitum,* and is exactly the same as Wharekuri shells. As I intended describing this form, I now present the photographs I had taken (Figs. 1, 2) of Wharekuri specimens, to show the normal adult appearance of the species. It is easily distinguished by its very even and regular sculpture of stout rounded radial ribs, rather distant and lamellose, the interstices 1½-2 times their width and quite smooth.

This also seems the best place to point out that Marwick, in his "Summary of New Zealand Pectinidae" (*Trans. N.Z. Inst.,* vol. 58, p. 453; 1928) has omitted the following four species from the genus *Chlamys*:—*zelandiae* Gray, 1843; *subantarctica* Hedley, 1916 (Macquarie Island); *williamsoni* Zittel, 1865 (Tertiary: Aotea, Auckland); and *grangei* Murdoch, 1924 (Upper Cretaceous; Brighton belemnite beds). To these *compitum* has also now to be added.

Genus *Chattonia* Marwick (p. 909). Type: *C. animula* n. sp.—This is a synonym of *Salaputium* Iredale (*Proc. Linn. Soc. N.S.W.,* vol. 49, pt. 3, p. 204; Oct. 24, 1924); type: *Crassatella fulvida* Ang. I noted in the "Further Commentary" (p. 458) that "*Salaputium* Iredale, given to a large series of Australian minute forms, has as yet no Neozelanic representative." *C. animula,* however, undoubtedly belongs to this group; it has smooth margins, but I now have another new species from Pakaurangi Point which has crenulated margins; the Australian forms are very numerous, and have both smooth and crenulated margins. They seem to be arrested stages in the development of the *Crassatellites* and *Spissatella* groups, and are often with difficulty separable from juveniles of the larger species. *Animula* occurs at Chatton in company with *Spissatella poroleda* Finlay, and also at Wharekuri with *S. subobesa* (M. & M.), but has uniformly denser sculpture, not smooth in the brephic stage, and a slightly different shape and hinge; it is truly adult and was rightly distinguished by Marwick. The new genus he made for it, however, must fall in synonymy.

Pholadidea increnata (p. 914).—I suggest that this is a synonym of *Martesia concentrica* Suter, 1917 (*N.Z.G.S. Pal. Bull. No. 5,* p. 79; Pl. 13, Fig. 9), from the lower tuffs, Broken River, Trelissick Basin. They are from approximately coaeval horizons, which are in both cases fairly shallow water beds. Dr. Marwick's shell is twice the size



Figs. 1, 2.—*Chlamys compitum* (Marwick): Wharekuri specimens × 1.5.

of Suter's, but otherwise no difference is observable. Both have a deep submedian furrow, strong concentric sculpture which is more lamellose anteriorly, a small anterior gape, no sign of callus plates, and are identical in shape.

Neither Suter's location in *Martesia,* nor Marwick's in *Pholadidea* can be upheld. Suter was influenced by the appearance on the posterior dorsal margin of a " a fairly large semioval sinus which is no doubt the place occupied by the protoplax." On account of the condition and preservation of the specimen, and Suter's many other errors of observation in this Bulletin, one may doubt the correctness of his inference; *increnata* shows no sign of this formation, and in any case the other shell characters are quite at variance with *Martesia.* The shape and extent of the anterior part of the shell alone make reference here impossible. *Martesia* and *Pholadidea* are both genera of Tryon's Subfamily Jouannetinae, distinguished, according to Dall (*Tert. Fauna Florida,* pt. 4, p. 818; 1898) by having the "Anterior gape closed in the adult by a calcareous deposit attached to either valve, and the edges of which meet in the middle line below; valves with one or more radial sulci, and with one or more accessory plates." The Subfamily Pholadinae, on the other hand, has the "Anterior hiatus permanently open, with no callum." It seems evident from the descriptions and figures of *concentrica* and *increnata* that they belong to the latter Subfamily; in this the median groove is an exception and is paralleled only by *Zirfaea* (Leach) Gray. That genus, however, has a large anterior gape, and the anterior end of the valve is shaped like *Barnea,* not regularly convex. *Talona* Gray has the front gape small, and a regularly rounded anterior end, but has strong radial sculpture and no groove. I can find no group to which the New Zealand form can be satisfactorily referred, so now propose

Zirlona n. gen; with type, *Pholadidea increnata* Marwick. A genus of the Pholadidae (Subfamily Pholadinae), with a small anterior gape, no callus plates closing the shell in front, but the anterior ends of the valves more or less rounded and approximating; a submedian deep oblique groove dividing the valves, the anterior portion bearing strong regularly spaced unsinuated concentric lamellae, but faintly crenulated, the posterior portion bearing low broad regular concentric folds; no radial sculpture; the dorsal margin somewhat concave and reflexed. Accessory plates unknown.

Although I think that there is but one New Zealand species so far known, and propose to call it *Zirlona concentrica* (Suter), I have named *increnata* as type since it is much the better preserved specimen, and may possibly prove distinguishable when more than one specimen from each locality is collected. Also, I have not seen either specimen, but am basing these notes on the figures and descriptions.

Tate (*Proc. Roy. Soc. N.S.W.,* vol. 31, p. 409; Pl. 20, Fig. 7a, b; 1897) has described an Australian Miocene species, found burrowing in coral, as *Martesia elegantula,* and indeed this seems much more like *Martesia,* and quite unlike the New Zealand form.

A true Tertiary species of *Pholadidea* has been described by Suter as *P. thomsoni* (*N.Z.G.S. Pal. Bull. No. 5,* p. 78; Pl. 10, Fig. 9; 1917) from Anthony Bay, Hauraki Peninsula, Auckland, found bor-

ing in shells of *Ostrea wuellerstorfi* Zitt. This seems the best place to record that I have obtained several specimens of the same species from Muddy Terrace, Waikaia, Southland, in exactly the same situation, only the host in this case was *O. wollastoni* Finlay. It is a well-marked form, with a very prominent callus closure in front, nearest, as Suter says, to *tridens* (Gray). Of this Recent species I have but one example, but this is abundantly distinct in shape and anterior ornament from *spathulata* (Sow.).

Antisolarium vixincisum (p. 915).—This is a *Conominolia,* not an *Antisolarium;* I can record it also from Muddy Terrace, Waikaia. *Conominolia* is always more elevated than *Antisolarium* (though *stoliczkai* is getting tall), has more deeply cut-in sutures (*i.e.,* whorls do not overlap), has many more or less equal spirals instead of a few very strong ridges, and has a thread in the umbilicus. This species has a striking superficial resemblance to *Philippia lutea* in miniature.

Elachorbis duplicarina (p. 915).—Dr. Marwick states that "The classification under *Elachorbis* is only provisional, for the two strong keels are not present in that genus." The Miocene *Cyclostrema helicoides* Hutton, from White Rock River, however, shows prominent keels, yet its genetic connection with the Recent Australian *tatei* Angas, through such Tertiary forms as *politus* Suter and *cingulatus* Bartrum and the Recent New Zealand *subtatei* Suter seems indisputable. Possibly two series are represented, but they all have the same embryo and aperture.

Proximitra incisula (p. 920).—This is a synonym of *P. ligata* (Suter) (*N.Z.G.S. Pal. Bull. No. 5,* p. 28; Pl. 4, Fig. 9), described as a *Vexillum,* from Wharekuri. So many of the Chatton and Wharekuri forms are identical that the occurrence of two Proximitras of this style is improbable, and my own specimens show that the correspondence is exact. Suter's type of *ligatum* is a small shell (9 by 4 mm.), but my largest specimen measures 14 by 6.2 mm., while Marwick's type is 12.5 by 6 mm. These dimensions indicate similar proportions, and the whole of Marwick's description applies exactly to *ligatum;* his distinguishing features hold good when applied to any other species, but not to this one.

I would refer *Mitra* (*Cancilla*) *armorica* Suter (*N.Z.G.S. Pal. Bull. No. 5,* p. 27; Pl. 12, Fig. 4) also to *Proximitra* as a close relative of *rutidoloma* the genotype (which occurs with it), but of smoother habit and less quadrate whorls; the embryonic features and aperture are identical. I did not refer to this species in the "Further Commentary," but gave figures of Otiake specimens in *Trans. N.Z. Inst.,* vol. 55, p. 468; Pl. 50, Figs. 4a, b.

New names proposed in this paper:—

Mauithoe n. gen. Type: *Mauia insignis* Marwick.
Zirlona n. gen. Type: *Pholadidea increnata* Marwick.

Revision of the New Zealand Shells Referred to *Fusinus.*

By H. J. FINLAY, D.Sc.

[*Read before the Otago Institute, 3rd December, 1929; issued separately, 23rd August, 1930.*]

PLATES 47–49.

Genus **Colus** Humphrey.

IN my " Further Commentary " (*Trans. N.Z. Inst.*, vol. 57, p. 407; Dec. 23, 1926) I noted that " The name *Colus* Humphrey, 1797 (*Mus. Calon*, p. 34) takes precedence over *Fusinus* Rafinesque, but the name is applicable in New Zealand only to some of the Lower Tertiary species." I then provided *Coluzea* n. gen. for one well-marked New Zealand Fusid lineage, and deferred treatment of the remaining species.

This statement may now be amplified and qualified. I describe below a number of new species of the *Colus* group, but give reasons for the dismissal of this name altogether from New Zealand lists, except in one doubtful case.

There is, however, so much confusion in the nomination of the described species that a review of the names already proposed is first necessary.

Suter lists the following New Zealand species (*Alph. List N.Z. Tert. Moll.*, p. 15; 1918) under *Fusinus*:—*bicarinatus* Suter, *climacotus* Suter, *congestus* Suter, *kaiparaensis* Suter, *morgani* Suter, *solidus* Suter, *spiralis* (A. Ad.), *spiralis dentatus* (Hutt.), and *tegens* (Hutt.). Since then the following have been described:

Fusinus corrugatus Marshall, 1918 (*Trans. N.Z. Inst.*, vol. 50, p. 264; Pl. 22, Figs. 9, 10). Pakaurangi Point, Kaipara.

Fusinus altus Marshall, 1919 (*l.c.*, vol. 51, p. 229; Pl. 16, F. 5). Hampden.

Fusinus maorium Marshall and Murdoch, 1919 (*l.c.*, vol. 51, p. 254; Pl. 21, Figs. 1, 2). Wharekuri.

Fusinus macrotegens Finlay and McDowall, 1923 (*l.c.*, vol. 54, p. 113; Pl. 2, F. 1; Text-Figs. 2). Dowling Bay, Dunedin.

Fusinus bensoni Allan, 1926 (*l.c.*, vol. 56, p. 339; Pl. 76, Figs. 4a, b). Waihao Downs. (*Non Fusus benzoni* Moerch, 1872).

Marshall and Murdoch record a " *Fusinus modestus* M. & M." from McCulloughs Bridge (*l.c.*, vol. 54, p. 118; 1923), but as Dr. Allan has noted (*l.c.*, vol. 56, p. 339; 1926) this is a *nomen nudum*. The same may be said of " *Fusinus pulcher* " and " *Fusinus carinatus* " recorded by Marshall (*Trans. N.Z. Inst.*, vol. 51, p. 243; 1919) from Wharekuri and " beds low in the system " in Canterbury respectively.

Of this series of species, *spiralis* A. Ad., *maorium* M. & M., and *climacotus* Suter have already been removed by me (*Trans. N.Z. Inst.*, vol. 57, p. 407; 1926) to the genus *Coluzea;* several of the remaining

names are synonyms, and some of the species must be referred to other genera and even families. These are as follows:

Fusus tegens Hutton, 1877 (*Trans. N.Z. Inst.*, vol. 9, p. 594), from White Rock River, belongs to the Muricidae, and I have already placed it in my genus *Vesanula*, created for the Ardgowan *V. chaskanon* Finlay (*l.c.*, vol. 56, p. 245; 1926), and located near *Xymenella* Finlay (*l.c.*, vol. 57, p. 427; 1926).

Fusinus congestus Suter, 1917 (*N.Z.G.S. Pal. Bull. No. 5*, p. 21; Pl. 12, F. 3) is a synonym of *V. tegens* (Hutt.). Examination of numerous topotypes leaves me in no doubt that *congestus* is described from a worn senile specimen, while *tegens* is from a not quite adult fresh shell. The apparent—but erroneous—dissimilarity between the two forms is heightened by the rather fanciful and sketchy figure of *tegens* given by Suter (*N.Z.G.S. Pal. Bull. No. 3*, P. 8, F. 6; 1915).

Fusinus bicarinatus Suter, 1917 (*N.Z.G.S. Pal. Bull. No. 5*, p. 20; Pl. 12, F. 1) is evidently an *Austrofusus* s. str. The holotype (which has been kindly loaned to me by the Geological Survey) is badly preserved, lacks the canal, and should never have been described. The fine equal spirals, absence of sutural cord, and outwardly directed nodules render it closer to *spinifer* (F. & McD.) and *glans* (Bolten) than to *precursor* Fin. and *affiliata* Fin., and the obsolescence of axial ribs between the nodules renders it closer to *glans*. On account of the narrow space between the two angles, and the presence of two strong ridges instead of three or a number on the lower angle, it may be retained as a distinct species, at all events till more material is examined. The most satisfactory solution would be to find—as is quite likely—the combination *Fusinus bicarinatus* preoccupied, when the name could be dropped.

Fusinus macrotegens Finlay and McDowell was reluctantly described, and has given me much perplexity; the unique holotype is very badly preserved, and again should not have been described. Though at the time it could not be well matched by either Dr. Marwick or myself, I have often felt that it ought to be a Target Gully form. I now suggest with some confidence that it is another synonym of *Tritonidea compacta* Suter, 1917 (*N.Z.G.S. Pal. Bull. No. 5*, p. 35; Pl. 4, F. 6), an extremely variable and common shell, which has already two synonymic names in *T. elatior* Suter, 1917 and *Euthria subcallimorpha* M. & M., 1921; the species therefore belongs to *Chathamina* Finlay and may be excised from the *Colus* group. The name *macrotegens* is a misnomer, the shell being nothing like *V. tegens*, which I had not seen at the time. In removing the last endemic species from the Dowling Bay list, this synonymy still further strengthens the correlation of that bed with the Awamoan. (See *Trans. N.Z. Inst.*, vol. 54, p. 110, footnote; 1923).

Fusinus morgani Suter, 1917 (*N.Z.G.S. Pal. Bull. No. 5*, p. 22; Pl. 3, F. 13) is an absolute synonym of *F. kaiparaensis* Suter, 1917, described on the previous page, from the same locality (Pakaurangi Point), *morgani* being founded on a slightly older specimen. My series of specimens shows every gradation between the two.

Fusinus altus Marshall is a very unsatisfactory species; described from a single battered specimen, uncleaned before being figured, it is impossible to recognise from the figure and meagre description

whether it is related to *solidus* Suter or *bensoni* Allan. Examination of the holotype, however, clearly shows that it is inseparable specifically from the Bortonian *bensoni*, which therefore becomes a synonym. This is a pity, since Dr. Allan's specimens are much better preserved. Here again, the best thing to hope for is that the name is preoccupied.

Fusinus corrugatus Marshall is also somewhat unsatisfactory, and in the absence of specimens no definite location can be made. It evidently does not belong to the *kaiparaensis-solidus* group, and the canal is too straight for alliance with *Siphonalia excelsa* Suter, which it suggests in sculpture. It is very like some Australian Balcombian Pleuroplocas, but Marshall makes no mention of any pillar plaits. On the whole, the closest resemblance to it seems to be shown by another characteristic Balcombian species, *Fusus dictyotis* Tate, 1888 (*Trans. Roy. Soc. S.A.*, vol. 10, p. 135; Pl. 7, Figs. 2, 6). This has a true *Colus* apex; paucispiral, globose, with axial acceleration at its close, so that *corrugatus* may remain at present as a *Colus s.l.* I have elsewhere noted (*Trans. N.Z. Inst.*, vol. 57, p. 504; 1927) that *Fusus corrugatus* Reeve is not congeneric with Marshall's shell, and does not invalidate his name.

Besides these, there are two species originally placed in quite a different group that should be referred here:—

Verconella delicatula Marshall and Murdoch, 1923 (*Trans. N.Z. Inst.*, vol. 54, p. 123; Pl. 14, Figs. 3, 4), compared by its authors to *Siphonalia excelsa* Suter, is not related to that species, having a widely different apex and pillar. Again, the examination of topotypes unfortunately compels me to reduce this species to a synonym of *Fusinus solidus* Suter, 1917 (*N.Z.G.S. Pal. Bull. No. 5*, p. 23; Pl. 3, F. 14). That shell was described from "Teaneraki (Enfield), near Oamaru, North Otago: T. Esdaile." Dr. Marwick has shown that the Esdaile collection is unreliably localised (*N.Z. Journ. Sci. & Tech.*, vol. 6, Nos. 5 and 6, p. 280; 1924), the bulk of the specimens being from the greensand, McCulloughs Bridge, Waihao River. This is also the type locality of *delicatula*, and the only feature in the shell which might seem to separate it from *solidus* is the twisted canal. But this is known to occur quite frequently in members of this Family; the Tasmanian *Colus novachollandiae* regularly shows an incipient curving, and it may occur sporadically in a species normally uncurved. A topotype of *Fusinus bensoni* Allan from Waihao Downs (Fig. 7) shows this very well; four normal specimens and this one were found together, and apart from the freakishly twisted canal the shells are identical, and can hardly be regarded as two species, much less as two genera. In all other details *delicatula* shows a corresponding identity with *solidus*, and I do not hesitate to unite them.

Euthriofusus tangituensis Marwick, 1926 (*Trans. N.Z. Inst.*, vol. 56, p. 320; Pl. 73, F. 9), described from G.S. locality 1142, Taranaki District, is not closely related to *Fasciolaria burdigalensis* Bast., the genotype of *Euthriofusus* Cossmann, but is very close to the species described below as *waiauensis* nov., and is certainly a member of this series—one of the last surviving in New Zealand, since it comes from Taranakian beds, which lie between the Miocene Awamoan and the Pliocene Waitotaran, in which no Fusids other than *Coluzea* have

been found. *Euthriofusus spinosus* Suter, 1917 (*N.Z.G.S. Pal. Bull. No. 5*, p. 24; Pl. 4, Figs. 1, 2) is not a Fusid shell; I have already made it the genotype of *Speightia*, a Turrid genus (*Trans. N.Z. Inst.*, vol. 56, p. 252; 1926).

The question now arises as to what generic name is to be used for this compact group. Grabau (*Phylogeny of Fusus*, 1904) has fully discussed *Colus* (as *Fusus*) and its divisions, and rightly placed considerable importance on the embryonic features. I emphatically agree with his dictum (p. 8) that "no species which does not show a protoconch similar to that of *Fusus colus*, the type of the genus, can be relegated to *Fusus*." The typical apex is described and figured by him as of "one and a half volutions, but may be somewhat shorter or longer. No case has been observed in which the protoconch consists of as few as one volution, and only one (*F. longirostris*) in which it consists of as many as two." In his description of *Murex colus* L. (p. 25) he continued by saying that the apex is "perfectly smooth for the first volution. The remaining half volution of the protoconch is ornamented by fine smooth vertical riblets . . . . ends abruptly with a strong varix." This is the type of apex seen in all the Australian Recent and Tertiary Fusid shells I have examined, but is not the type found in the New Zealand series. This is polygyrate and conical, and agrees much better with the apex described by Grabau (p. 80) for his new genus *Falsifusus*, as follows: "Protoconch merging into the whorls of the conch, no sharp line of demarkation being apparent. The first two whorls are generally smooth, the apical one minute, gradually increasing in size. The 3-4 whorls which constitute the apical series form a rather narrow cone. Third whorl with fine closely crowded more or less oblique riblets, which in part are gently concave forward. These . . . . quickly merge into the normal whorls of the conch. A basal carina usually marks the ribbed whorls of the apical series, this carina appearing just above the suture." This accurately portrays the apices of the New Zealand series, except that the basal carina is less in evidence, and there are only a few axial riblets. But although the apex agrees, the shell characters of the New Zealand forms are considerably different from the North American Eocene *Falsifusus*, so that it becomes necessary to place them in a new division. *Euthriofusus* Cossmann more resembles the New Zealand forms in shape and has an apex of the same general type; but its excavated inner lip with the characteristic strong parietal ridge much more sinuous and produced outer lip, wider and shorter spire, and different development of axial nodules, all prevent reference of our shells to that European Tertiary genus.

Falsicolus gen. nov.

A genus of the Colidae, related to *Falsifusus* Grabau, and with the same polygyrate pointed protoconch, ending in a few curved axial riblets, but with a much more solid and less elongate shell, with less marked keel on whorls, much denser and less regular spiral sculpture, and a not perfectly straight canal, a low and blunt but rather heavy angular oblique ridge marking a twist at the base of the aperture, the canal thenceforth bent lightly to the left, but with a tendency to curve slightly round again; inner lip totally unraised, usually even

a little sunken, grading into canal and basal sculpture. In the type and some other species there is a progressive development of heavy axial knobs on periphery; in another series there is progressive obsolescence of axial sculpture, the later whorls having only spirals.

Type: *Fusinus kaiparaensis* Suter, 1917 (= *morgani* Suter, 1917) (Suter's good figures of this species—*N.Z.G.S. Pal. Bull. No. 5;* Pl. 3, F. 13, and Pl. 12, F. 2—well show the characteristic shell formation of the type).

Apart from *Coluzea, Falsicolus* will cover every New Zealand Tertiary species except *corrugatus* Marshall. It is surprising that true *Colus* is unrepresented in New Zealand (*corrugatus* and *dictyotis* Tate are not at all normal; several Australian groups will later be separated from true *Colus,* represented there by the Recent *australis* Q. & G. and *novae-hollandiae* Reeve), and just as surprising that *Falsicolus* seems to be unrepresented in Australia. Our earliest species, *altus* Marshall, is somewhat like the American *Falsifusus* forms, but already shows all the separative characters mentioned in the diagnosis, so that the derivation of the lineage in New Zealand is obscure.

Falsicolus obrutus n. sp. (Figs. 5, 6).

First few whorls, aperture, and canal missing, portions of other whorls worn off, but enough remains to charactertise the species. Whorls sharply medially keeled, the shoulder sloping at about 45 degrees, steeper below keel. Spirals dense and inconspicuous on shoulder (2-3 fine threads between coarser ones), a strong narrow cord on keel, three almost as strong between it and suture, and numerous similar ones on base; generally three fine spirals intercalated between all these; suture margined by a rather prominent swelling. Axials strong and distant, 7 per whorl, first their own width apart, then twice, and finally on body whorl thrice; prominent from suture to suture, jutting out at keel into sharp horizontally compressed points, regularly and rapidly dying away on base. A blunt subangulation emerges from suture line on base, but there is no second carina, and the axials are not more prominent there.

Height, 24 mm.; width, 14 mm. (incomplete shell).

Locality—Kakanui Tuffs, on the beach, below the limestone (Waiarekan), one specimen.

Holotype in Finlay collection.

This is probably the "*Fusinus* sp." mentioned by Marwick (*Trans. N.Z. Inst.,* vol. 56, p. 308; 1926) as occurring in the Waiarekan tuffs at Lorne.

Falsicolus allani n. sp. (Fig. 3).

Generally similar to *obrutus* in type of sculpture, but relatively wider and with a less slender spire. Spiral sculpture same, main spirals below keel perhaps a little more crowded. Axials 7 per whorl, except on body whorl where there are 6, relatively much wider and heavier than in *obrutus,* 1½ times their width apart on upper whorls, twice at most on last whorl, considerably more expanded and horizontally projecting on keel, which is not median but distinctly nearer lower suture. Instead of a blunt subangulation a second (but much lower) carina emerges from suture on to base, on it the axials are

again raised into sharp tubercles, though much weaker than those on keel. Spire rather low for the genus, not nearly as long as canal.

Height, 50 mm.; of spire, 15 mm.; of canal, 24 mm.; width, 23 mm.

Locality—Wharekuri greensands (Ototaran ?), one specimen, collected by Dr. R. S. Allan.

Holotype in Finlay collection.

This simulates *kaiparaensis* in strength and arrangement of keel nodules, but has a lower spire, longer canal, no prominent secondary cord below keel, a higher keel with a second carina on base, and finer spiral sculpture on base.

Falsicolus eoaffinis n. sp. (Fig. 11).

Very similar to *solidus* Suter, but a less massive shell with weaker sculpture. Shape of whorls and sub-keel and relative dimensions same as in *solidus*. 12-13 axials per whorl, as in *solidus*, but weaker and shorter (hardly half height of whorl instead of well over half), with U-shaper shallow interstices almost as wide as ribs (instead of V-shaped and much narrower than ribs). Spiral sculpture considerably weaker, though of same general arrangement; the three main cords on lower half of spire whorls and the numerous strong basal and canal cords of *solidus* being of little prominence; especially on the canal the spirals are thin threads, 4-6 times their width apart instead of heavy cords with narrower interstices. Pillar much less stout than in *solidus;* outer lip broken, but details of aperture probably as in *excellens* (described below).

Height, 47 mm.; of spire, 19 mm.; of canal, 15 mm.; width, 16 mm.

Locality—Clifden (band 6B) (Hutchinsonian).

Type in Finlay collection.

Falsicolus excellens n. sp. (Fig. 4).

Shell close to and evidently derived from *eoaffinis*. The early whorls are practically the same, but the angle of the spire is a little greater. The spirals on shoulder remain as in that species on all whorls; on canal they are somewhat heavier and closer, but on body whorl and below shoulder on spire whorls they are much stronger and more prominent, at first 3 and then 4 (the fourth at the suture) being very prominent on all whorls. On body whorl there are some 10 strong raised spiral cords, 3-4 times their width apart, with 4-7 interstitial threads, the median one more prominent, the others hair-like; the three spirals on periphery of body whorl are closer together, and the upmost and lowest undulate in opposite directions. On the early whorls the axials are narrower, sharper, and more distant (3 times their width apart), on antepenultimate whorl they are becoming slightly stouter and more rounded (twice width apart), while on penultimate whorl they are considerably wider (own width apart) and raised on periphery into stout squarish tubercles, about 13 on the whorl; about 10 on body whorl, where they are still stouter and more projecting; they are semi-cylindrical in shape and are really extremely short and stout axial ribs; below and above them the axials are practically absent, not reaching either suture. Growth lines dense and prominent but irregular, markedly antecurrent on shoulder, showing a Verconellid sinus on keel. Whorls tightly clasping, bluntly

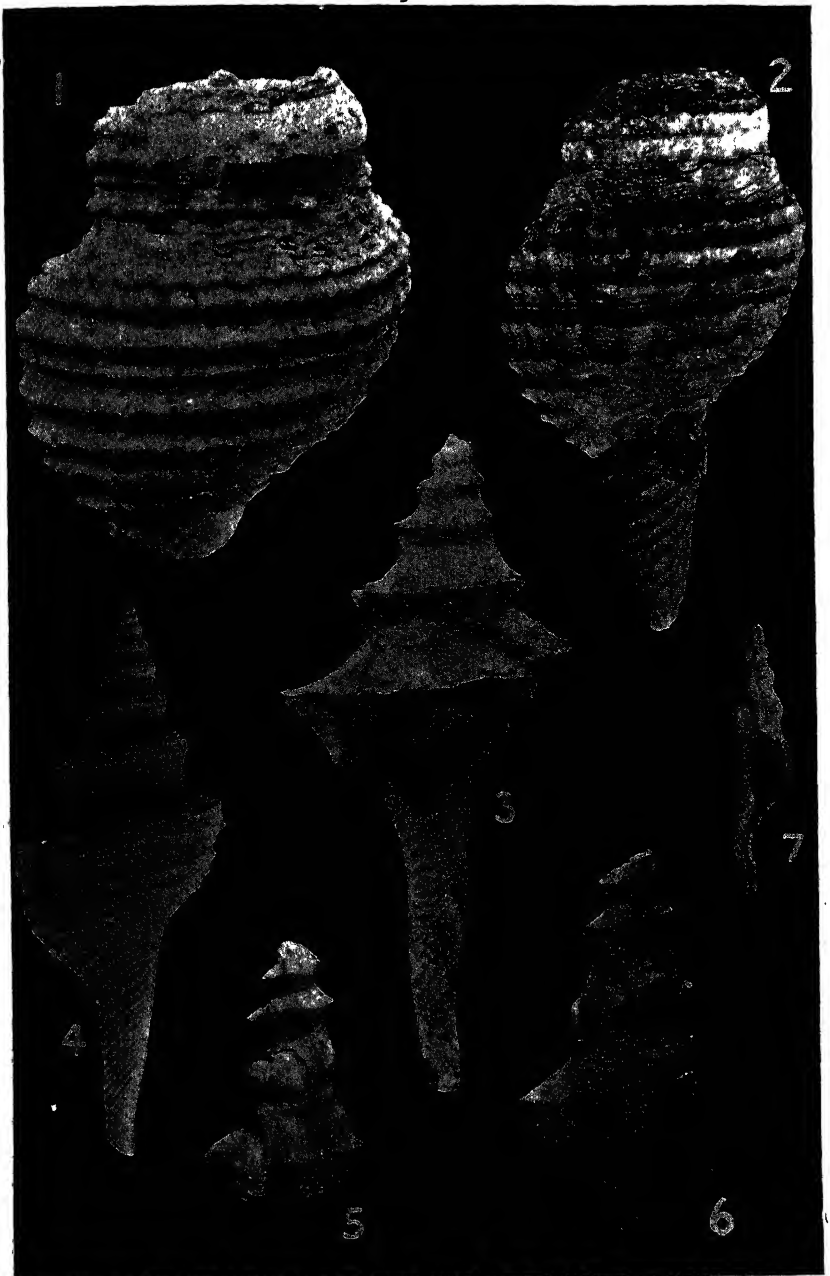


FIG. 1.—*Falsicolus coerulescens* n. sp., holotype × 2.6.
FIG. 2.—*Falsicolus waiauensis* n. sp.: holotype ×1.5.
FIG. 3.—*Falsicolus allani* n. sp.: holotype × 1.7.
FIG. 4.—*Falsicolus excellens* n. sp.: holotype × 1.2.
FIGS. 5, 6.—*Falsicolus obrutus* n. sp. holotype ×1½ and 2.
FIG. 7.—*Falsicolus bensoni* (Allan): topotype, with twisted canal × 1.

Face p. 264.

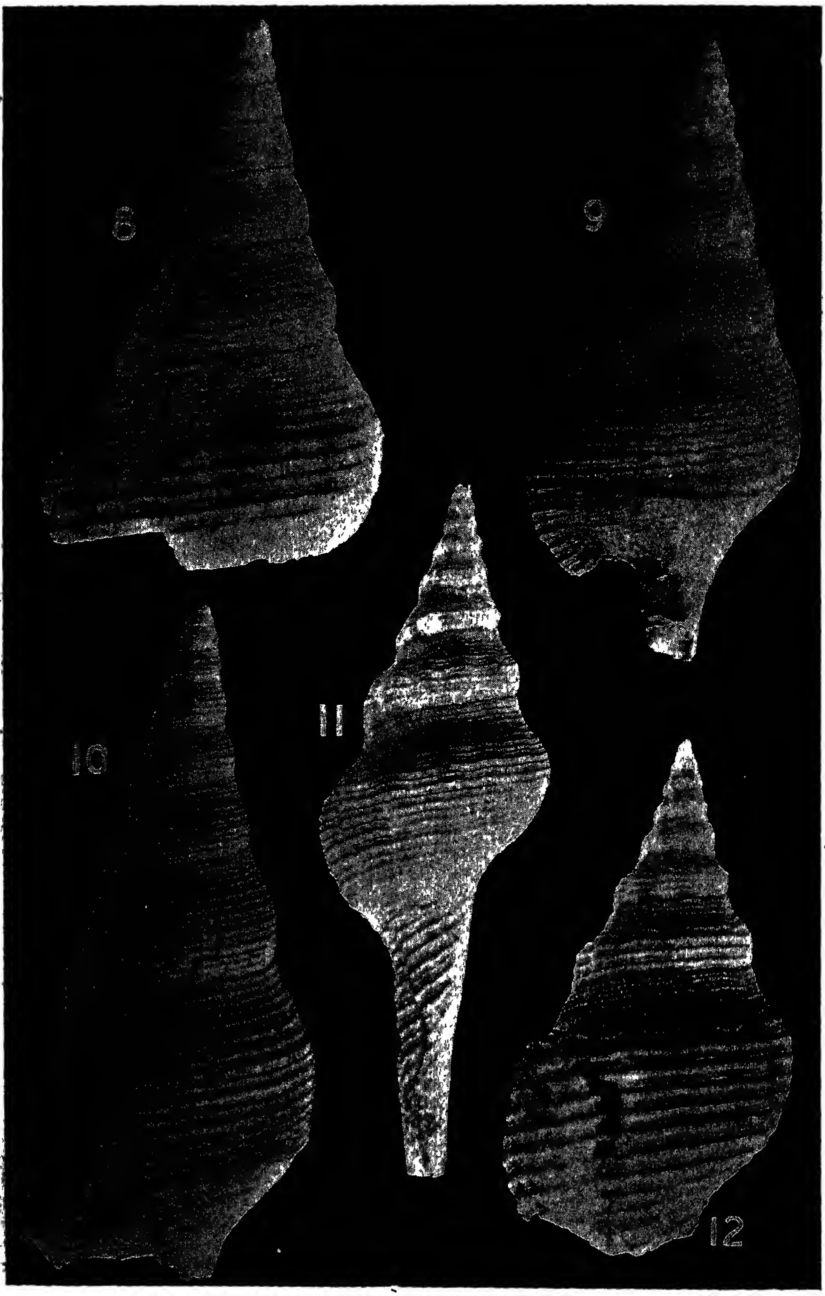


FIG. 9.—*Falsicolus levatus* n. sp.: holotype × 4.5.
FIG. 8.—*Falsicolus* n. sp. aff. *levatus* Finlay: Blue Cliffs × 4.
FIG. 10.—*Falsicolus levatus* n.sp.: paratype, Awamoa × 4.
FIG. 11.—*Falsicolus eoaffinis* n. sp.: holotype × 2.
FIG. 12.—*Falsicolus* n. sp. aff. *waiauensis* (?) Finlay: Clifden × 3.

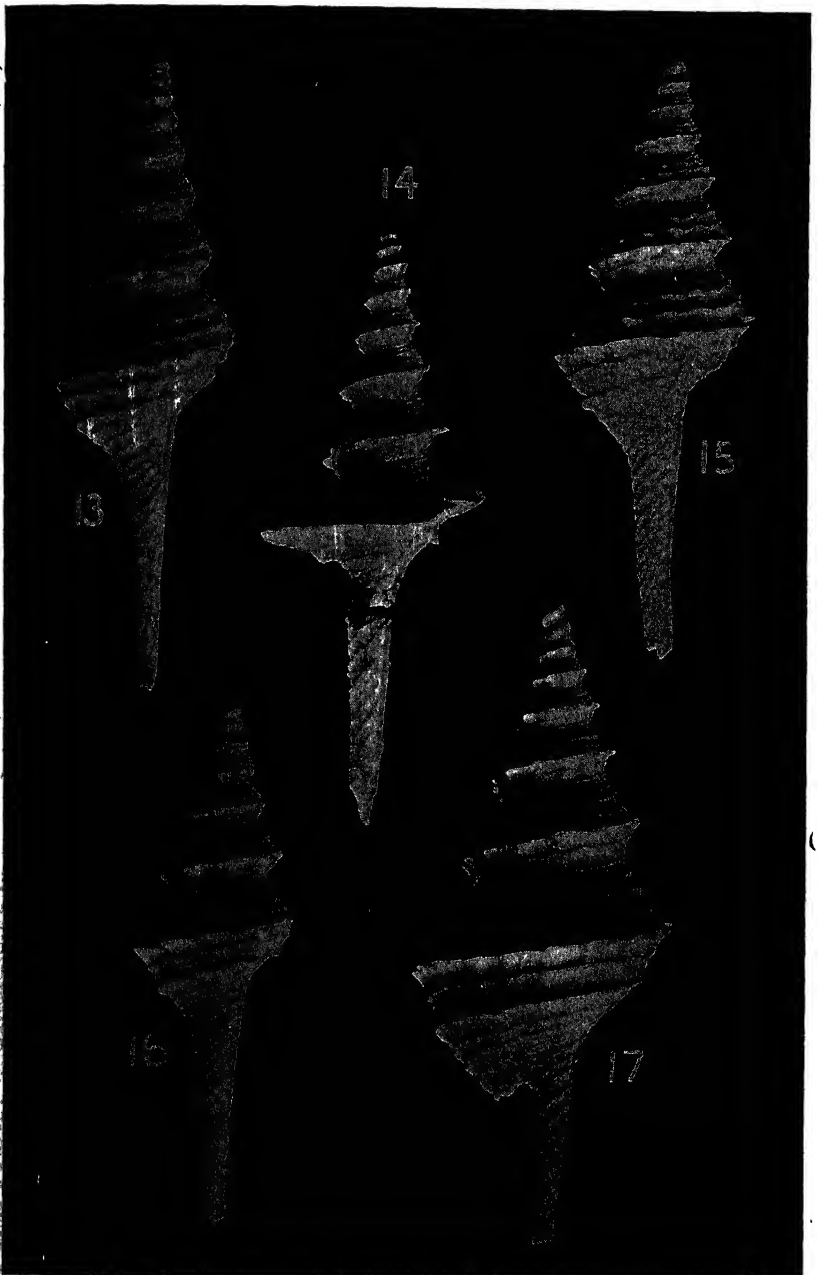


Fig. 13.—*Colusea macrior* n. sp.: holotype × 2.7.
Fig. 14.—*Colusea kiosk* n. sp.: holotype × 1.7.
Fig. 15.—*Colusea dentata* (Hutton): holotype × 2.2.
Fig. 16.—*Colusea paucispinosa* n. sp.: holotype × 3.8.
Fig. 17.—*Colusea dentata* (Hutton): Rifle Butts specimens × 3.4.

but strongly keeled a trifle below middle, shoulder lightly concave, sutures inconspicuous, margined above. Aperture as in *solidus,* with same (but somewhat weaker) short internal crenulations. Spire higher than canal.

Height, 59 mm.; of spire, 23 mm.; of canal (minus tip), 19 mm.; width, 23 mm.

Locality—Clifden (band 6c) (Hutchinsonian), one almost perfect shell and a fragment.

Type in Finlay collection.

Falsicolus n. sp. (?). (Fig. 12).

A fragment (lacking aperture and canal) was collected by Prof. Park at Clifden, and as far as I can make out from his notes, comes from band 6c. It does not agree exactly with either *eoaffinis* or *excellens,* though nearer to the former. It differs in its narrower shoulder, more quadrate whorl, much more regular main spirals (a numerous, equidistant, and perfectly even series of these covering body whorl except on shoulder, 1½ times own width apart, and with 3-4 regular hair threads in interstices) and extremely dense and regular reticulation caused by axial threads, finer even than the interstitial spirals. The main axials are narrower, longer, and less prominent than in either *eoaffinis* or *excellens.*

Height of spire, 15 mm.; width, 13 mm.

Locality—Clifden (band 6c ?—possibly from slightly higher beds) (Hutchinsonian).

Although fragmentary, this form seems distinct from its congeners in these beds. On account of its condition and rather indeterminate horizon it is not given a name, but is figured and described here on account of its connecting relationship between *excellens* and *waiauensis* (see below); possibly it is the young of *waiauensis* and comes from the basal beds of band 7.

Falsicolus waiauensis n. sp. (Fig. 2).

Shell large and massive for the group, spire lost in both specimens. Shoulder concave, the periphery submedian, bluntly angled, thence slightly oblique. Spirals narrow and fine on shoulder, four strong cords on lower ⅔ of whorl, topmost on lower part of shoulder, second on peripheral angulation, third midway between this and the lowest, which is at suture. About 8 similar strong distant spirals on body whorl, 4-5 times their width apart, and some 15 slightly weaker but still prominent oblique cords on canal; interstices with 8 or more fine hair threads, the median one stronger. Axials rude and numerous, not very prominent, about 17-18 on body whorl (about 15 on penultimate), very similar to those of *solidus* in shape and spacing, less than own width apart, low and irregular on shoulder (which they undulate), strong down to suture and on body whorl down to lower subangulation, thence rapidly fading on to canal. Body whorl forms a considerable squarish bulge instead of a rather narrowly convex swelling as in *eoaffinis* and *excellens.* Canal seems rather short; pillar massive, exactly as in *solidus;* outer lip also same.

Height (of body whorl and canal), 49 mm.; width, 28 mm.

Locality—Clifden (band 7c) (Hutchinsonian).

Type in Finlay collection.

This seems very close to the Taranakian *Euthriofusus tangituensis* Marwick, but that species has a sharper periphery, fewer axials, interrupted sculpture, probably a lower spire, and seems to be a smaller shell.

Falsicolus coerulescens n. sp. (Fig. 1).

Closely related to *waiauensis,* but with finer and denser sculpture. Spirals much the same in number and arrangement, but higher, sharper, and closer (2-4 times their width apart), with only 3-4 interstitial riblets. Axials very numerous, 19 on penultimate whorl, increasing to about 29 on body whorl, narrow and high and distant on the former, still narrower but lower on the latter (about 3 times their width apart everywhere), only a little diminished on shoulder, extending from suture on to inception of canal. Outer lip, canal, and spire missing, but otherwise as in *waiauensis.*

Width, 21 mm.

Locality — Blue Cliffs, Tewaewae Bay, Southland (Hutchinsonian?).

Type in Finlay collection.

Falsicolus levatus n. sp. (Figs. 9, 10).

Shell differing at sight from the other members of the group in its smoothness, axial sculpture being practically absent. Spirals regular and fine over whole surface, though they may be alternately a little weaker and stronger. Axials reduced to first four whorls, where they number 11 per whorl, extending as elongated knobs from halfway up shoulder to suture below, about own width apart, entirely absent on last three whorls, which are regularly convex except for a slightly concave shoulder. Apex quite typical, sharply conical (its angle more obtuse than that of the spire), of over three smooth convex whorls, the tip small but globose, two curved axials at its close, then merging directly into adult sculpture. Pillar also shows the characteristic twist and oblique ridge.

Height, 18 mm.; width 8 mm. (type, lacking most of canal, and somewhat crushed).

Locality—Otiake, sandy beds above limestone (Hutchinsonian), type and two others. Also Wharekuri greensands (Ototaran ?) and Awamoa, blue clays on banks of stream (Awamoan).

Type in Finlay collection.

Although superficially of different appearance from the other species, this seems easily derived from such a form as *coaffinis* by suppression of the axials and weakening of the main spirals (already weaker in that species than in the others).

What seems to be another species of this line occurs at Blue Cliffs, Otaio River (Fig. 8). It is not described, since only a single imperfect specimen is known to me, but it seems relatively wider than *levatus,* the axials appear faintly only on the first whorl, then are entirely lost till the body whorl, when they show signs of reappearing and producing an angled periphery. It is possible that adult specimens might show its alliance to *tangituensis* Marwick, which also loses its axials on the third whorl, but which otherwise seems much more like *waiauensis.*

Genus **Coluzea** Allan, 1926.

I have explained in another paper in this volume that the name *Coluzea,* proposed by me (*Trans. N.Z. Inst.,* vol. 57, p. 407; Dec. 23, 1926) with the Recent *Fusus spiralis* A. Ad. as type, must be attributed to Allan, who had previously introduced it (*l.c.,* p. 304; Dec. 7, 1926) in connection with the Miocene species *Fusus dentatus* Hutton, which therefore becomes the type by monotypy.

Powell (*Trans. N.Z. Inst.,* vol. 58, p. 298; 1927) has remarked that "The exact generic place must remain in doubt until the radula of *spiralis* is known, as the shells of *Columbarium* and *Coluzea* are remarkably similar," and notes that Peile has placed *Columbarium* near the Muricidae. The shell habit and bulbous apex, however, are so different from the Muricoid genera that the best course seems to be to follow Tomlin (*Ann. S. African Museum,* vol. 25, pt. 2, p. 330; 1929) and place these elegant forms in a separate family Columbariidae, which Tomlin defines as having "near relationship on one side to the Muricidae; a more remote one possibly on the other side to the Buccinidae." He also points out that the operculum of *Columbarium* has an apical nucleus, not subapical as in typical Murices, and is not unguiform in shape, but "pear-shaped, narrowing very regularly and rapidly on either side to an acute point."

Coluzea, as Powell states, is so like *Columbarium* in general style that, although the operculum and dentition of *spiralis* are unknown, I suggest its reference to Family Columbariidae in preference to Colidae. It is practically a *Columbarium* with a higher spire, keeled embryo flattened on top, and regular distant spirals. The name is worth retaining, as the New Zealand lineage is amply distinct from typical *Columbarium.* The genotype of the latter is *Pleurotoma* (*Columbarium*) *spinicinctum* von Martens, 1881, a Recent species from 76 fathoms east of Noosa Heads, Queensland; it has also been recorded (under the synonymic name *pagodoides* Watson) from 80-410 fathoms off Sydney, N.S.W., by Hedley (*Rec. Austr. Mus.,* vol. 13, No. 6, p. 225; 1922). *Fusus acanthostephes* and *foliacea* Tate (*Trans. Roy. Soc. S.A.,* vol. 10, p. 132 and 133; 1888) are undoubtedly on the ancestral line of this species, and these and other Balcombian and Janjukian Australian forms have a uniformly lower spire, more elaborate and frilled ornament, and less deeply cut-in sutures than *Coluzea,* which I have not seen from Australia. Chapman (*Proc. Roy. Soc. Vict.,* vol. 35, N.S., pt. 1, p. 14; Pl. 3, F. 20; Dec., 1922) has described *Fusinus youngi,* which he compares to the New Zealand *climacota* Suter. The Australian shell seems not unlike a *Coluzea,* but the figure is out of focus; it may be a true *Colus.* The nearest approach to *Coluzea* from outside New Zealand seems to be *Columbarium formosissimum* Tomlin (*l.c.,* p. 331; Pl. 25, F. 1) from 90 fathoms, 65 miles off Cape St. Blaize, South Africa.

I would also suggest the reference of *Fulgurofusus* Grabau to the Family Columbariidae. This is an American Eocene genus which has an apex and style of shell strikingly similar to *Coluzea.* Grabau describes the protoconch as "Fulguroid, consisting of one whorl, which is smooth, obliquely erect, and with a prominent apex. The conch is not distinctly separated from the protoconch, and is very early marked by an angulation and a basal carina." The genus is

less advanced than *Coluzea,* the angulation not having been impressed on the embryo proper, which is also of fewer turns; also the shoulder is practically smooth, and the axials less developed on the upper part of the whorl. Nevertheless, the affinity must be close, for the essential features are much the same, and Grabau's figure of *Fusus quercollis* Harris, the genotype, could almost stand for the upper whorls of an early *Coluzea,* such as *kiosk* Finlay (see below). It seems likely that *Coluzea,* which is an ancient New Zealand genus, came to us from America, and has long been separated from the Australian *Columbarium.* Cossmann (*Ess. Pal. Comp.,* livr. 7, p. 227; July, 1906) rejected *Fulgurofusus* as imperceptibly different from *Fusus* (i.e., *Colus*), but as he also thought *Falsifusus* a synonym of *Fusus,* one need not pay too much heed to his dictum.

Coluzea spiralis (A. Ad.)

1856. *Fusus spiralis* A. Adams, *Proc. Zool. Soc.* (*Lond.*) for 1855, p. 221.
1873. *Fusus pensum* Hutton, *Cat. Mar. Moll.,* p. 8.
1880. *Fusus spiralis* A. Ad.: Hutton, *Man. N.Z. Moll.,* p. 50.
1881. *Fusus spiralis* A. Ad.: Tryon, *Man. Conch.,* ser. 1, vol. 3, pp. 68 and 227; Pl. 85, F. 593.
1884. *Fusus spiralis* A. Ad.: Hutton, *Trans. N.Z. Inst.,* vol. 16, p. 227.
1893. *Fusus spiralis* A. Ad.: Hutton, *Macleay Mem. Vol.,* Plioc. Moll., p. 40; Pl. 6, F. 9.
1913. *Fusinus spiralis* (A. Ad.): Suter, *Man. N.Z. Moll.,* p. 357; Pl. 41, F. 4 (poor figure, possibly from a Petane Pliocene specimen, which is a distinct species).
1915. *Columbarium suteri* Smith, *Brit. Antarct. " Terra Nova " Exped.,* 1910, vol. 2, No. 4, p. 87; Pl. 1, F. 30.
1916. *Columbarium suteri* Smith: Mestayer, *Trans. N.Z. Inst.,* vol. 48, p. 126; Pl. 12, F. 8.
1924. *Fusinus spiralis* (A. Ad.): Bucknill, *Sea Shells of New Zealand,* p. 60; Pl. 7, No. 17 (good figure).
1926. *Coluzea spiralis* (A. Ad.): Finlay, *Trans. N.Z. Inst.,* vol. 57, p. 407.
1927. *Coluzea spiralis* (A. Ad.): Powell, *Trans. N.Z.* Inst., vol. 58, p. 298; Pl. 34, F. 3 (puts *suteri* as a synonym).

This species is restricted to the Recent fauna and the upmost Pliocene Castlecliffian stage. I quite agree with Powell's action in synonymising *Columbarium suteri* E. A. Smith.

Coluzea espinosa n. sp.

Very close to *spiralis* A. Ad., but with a considerably lower spire (less than canal; equal to canal in the Recent species); a more narrowly channelled suture, due to the closer approximation of the topmost shoulder cord and the ridge below keel; considerably stronger spiral sculpture on the shoulder (4 rather heavy cords instead of thin ridges), which itself is more steeply sloping; and a much smoother appearance owing to the obsolescence of the keel spines on the last two whorls and their much weaker development on the upper whorls.

Height, 69 mm.; width, 19 mm.

Locality—Petane, blue clays (Nukumaruan).

Type in Finlay collection.

This is still a long way from *dentata* (Hutton), but it is nearer to it than is *spiralis*. Of the latter I have seen no Recent specimens, and have made comparisons only with Castlecliff shells (Upper Pliocene), but from the figures of *Columbarium suteri* published by Miss Mestayer and Powell, and its author's original figure, there seems to be no difference between Recent and Castlecliffian examples.

Possibly Suter's figure of *spiralis* in the "Atlas" was taken from a Petane fossil, and represents this species; it seems to have the high spire of *spiralis*, but the sculpture is so badly drawn that identification is uncertain.

Coluzea dentata (Hutton). (Figs. 15, 16).

1877. *Fusus dentatus* Hutton, *Trans. N.Z. Inst.*, vol. 9, p. 594.

1887. *Fusus dentatus* Hutton, *Proc. Linn. Soc. N.S.W.*, ser. 2, vol. 1, p. 207.

1915. *Fusinus spiralis* A. Ad., sub sp. *dentatus* (Hutt.) : Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 18.

1926. *Coluzea dentata* (Hutton) : Allan, *Trans. N.Z. Inst.*, vol. 57, p. 304.

1926. *Coluzea dentata* (Hutton) : Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 407.

As no figure of the type (from Mt. Harris, in Otago Museum, Dunedin) of this species has yet appeared, I now present one (Fig. 15). For comparison I also present a figure (Fig. 16) of a specimen from the Rifle Butts, Oamaru (Awamoan sandy beds, uppermost horizon). This shows a style of apex essentially similar to that of the Recent *spiralis*, but not so bulbous.

This species is restricted to the Awamoan stage, and I have it from Target Gully, Ardgowan, Pukeuri, Awamoa, and Rifle Butts, in addition to the type locality, Mt. Harris.

Coluzea macrior n. sp. (Fig. 13).

Very close to *dentata* (Hutt.), but constantly more slender. The keel is blunter, lacking the horizontal lamellar carina of *dentata*, and the spines are much weaker. The number and arrangement of the spirals and axials are the same, but the axials tend to be ruder, and so appear closer together, about 1½ times their width apart, instead of 2-3 times. The lower carina on the body whorl is weaker, and the protoconch slightly larger and better keeled. Otherwise there is no difference between the two species, which occur together at Target Gully and Ardgowan, though at typical Awamoan localities such as Pukeuri, Mt. Harris, Awamoa, and Rifle Butts, only *dentata* occurs.

Height, 30 mm.; width, 9 mm.

Locality—Ardgowan "shell-bed," near Devil's Bridge, Oamaru (Awamoan), type and five damaged shells; also Target Gully (Awamoan), four broken shells.

Type in Finlay collection.

Fusinus maorium M. & M. is also very similar to this species, but is a larger and heavier shell, not so slender, with apparently still ruder and closer axials, and four distant spiral cords on shoulder instead of three (which seems to be constant in *macrior*. But as this character varies in other species of the lineage, it probably varies

here also). Moreover, a still more distinct species occurs in the intervening Otiake beds.

Coluzea paucispinosa n. sp. (Fig. 16).

This is again very close to *dentata* (Hutt.) but differs in the accentuation of axial sculpture at the expense of the spirals. There are only 9 axials per whorl (the type is not adult, but at the same stage *dentata* has 12), well marked on shoulder and below keel, about three times their width apart. The spirals are much weaker on the shoulder, 4 in number; the keel is placed a little higher on the whorls, and tends to point upwards instead of horizontally. The embryo is notably smaller and shows no trace of a keel.

Height, 18 mm.; width, 6 mm.

Locality—Otiake, sandy beds above limestone (Hutchinsonian), type and three fragmentary shells.

Type in Finlay collection.

The spiral sculpture in *maorium* is strong, and the axials about 12 per whorl as in *dentata* and *macrior*.

Coluzea kiosk n. sp. (Fig. 14).

Shell extremely slender and elegantly coiled, periphery of later whorls progressively more and more expanded into a wide horizontally frilled platform. Embryo, like the shell, very tall (somewhat Verconelliform), of three whorls, the last keeled below middle, the tip Caricelloid, but worn. Succeeding shell whorls at least 8 (probably 9-10 is the extreme), strongly and sharply keeled a little below middle, with a straight slope above and below. This keel projects horizontally more and more on each whorl, till on the body whorl there is a lamellar frilled platform jutting out for a distance equal to shoulder; it is made up of foliaceous expansions of the serrations, webbed together like a duck's foot. The axials number about 15-17 per whorl, and are practically confined to the serrations, being weak on shoulder and just below keel on upper whorls, absent on lower whorls. Three thin distant spiral raised threads on shoulder; suture closely margined on either side by a pair of fine threads; and one stronger spiral ridge below keel, nearer suture. Canal with very distant thin spinose raised threads; equal to spire in length.

Height, 47 mm.; width (across frill), 19 mm. Fragments show that this size is greatly exceeded, a canal alone measuring 50 mm., so that the whole shell would reach about 120 mm. in length. This must be a magnificent species when fully grown.

Locality—Clifden (band 6A, type; also 4B, fragments) (Hutchinsonian).

Type in Finlay collection.

This cannot be confounded with any other species, being the most bizarre of the group. *C. climacota* (Suter) has deeper sutures, a much blunter keel, and strong axials and spirals, being indeed on the same line as *dentata* and *macrior;* close to the latter, but still more slender, and with blunter keel, and more deeply channelled sutures. *Climacota, maoria, macrior,* and *dentata* form a very homogeneous line, from which *kiosk* and *paucispinosa* are perhaps offshoots. There is a gap between the Miocene *dentata* and the Recent *spiralis* which requires to be bridged by the discovery of Pliocene connecting links, one of which has been here described as *C. espinosa.*

A Revision of New Zealand Ephemeroptera.

PART 1.

By CAPT. J. S. PHILLIPS, M.C., M.A. (Oxon), F.R.G.S.

[*Issued separately, 23rd August, 1930.*]

PLATES 50–60.

CONTENTS.

THE order EPHEMEROPTERA is a small division of insects, previously included under the heading of NEUROPTERA.

Mayflies spend almost the whole of their existence under water and in the nymphal stage.

The majority of species prefer the fast-flowing or moderately fast-flowing type of waters, and so New Zealand, with its abundance of hill streams, is a particularly favourable country for their existence.

As far as is known at present, our mayflies are entirely endemic, but they show affinities to Australian species.

Some of our larger flies of the family SIPHLONURIDAE are of great interest, as they are of an archaic type and unlike any found outside Australasia.

The only economic importance of this order is as the food of fresh-water fish and, as I have shown elsewhere (15) they form about ten per cent. of the food of the acclimatised brown trout (*Salmo fario*) in New Zealand.

In this connection, it has been stated that our larger and less agile mayflies, notably *Oniscigaster*, are being exterminated by the trout. Whilst it is certain that they have been very seriously depleted, the stream beds are so very uneven that there will always be plenty of refuge places for the nymphs of mayflies, inaccessible to trout and indeed I have found *Oniscigaster* in streams which abound in trout.

A far more serious danger is the acclimatised bird, and to a lesser extent the native bird, now that the river banks have been cleared of bush in most places, for in the winged stages—particularly in the sluggish sub-imaginal one—the mayfly falls an easy prey.

Past Work.

Apart from one or two isolated examples (19), (24), (25), (26), (27) and (28), New Zealand EPHEMEROPTERA were first described by Eaton, who in 1871 (17) published an account of four of our species.

Later, in his monumental work (4), Eaton included descriptions of six New Zealand mayflies, and in 1899 (5) these descriptions were amended, enlarged and new species added, so that this last paper dealt with ten species. Altogether, Eaton described eleven of our species, but with the exception of *Oniscigaster wakefieldi,* he did not give any accounts of the nymphal stages, which at that date were mainly unidentified.

Hutton, writing in 1898 (2), included short notes of seven species among accounts of the local NEUROPTERA, but among these was an Australian species, not found here, *Atalophlebia costalis*, which McLachlan thought would probably be found here as well; and Lillie, writing in 1898 (3) and 1901 (18), dealt with three species. The latter writer bred his flies from the nymphal stage, and was, therefore, able to include the nymphs in his descriptions. His unknown nymph (18) is *Coloburiscus humeralis.*

In 1904, Hudson published a book on *New Zealand Neuroptera* (1), which included short accounts of twelve mayflies with one new species, *Atalophlebia cruentata*: it included brief descriptions of many of the nymphs, extracts from Eaton describing the winged stages and much original information concerning habitat and life history.

For nearly twenty years, no further work was published till in 1923, Tillyard (6) described some of the stages of two new mayflies, *Ichthybotus bicolor* and *Ameletus flavitinctus.*

In the same year appeared his paper on *The Wing Venation of the Plectoptera* (16), a work which greatly altered all pre-existing ideas on the subject. His studies were made on New Zealand mayflies of the family Siphlonuridae.

Since then, his wing-vein designations have been slightly modified and the remodelled nomenclature appears in his book (7). This also gives a key to families and some remarks on the species.

The present paper is an attempt to fill up the gaps. It deals with twenty species, some of them new, and gives particulars of the undescribed (generally nymphal) stages of adults known for many years.

The nymphs were collected in the neighbourhood of Wellington for three consecutive seasons and bred in separate compartments of an aquarium at Victoria University College.

Life Cycle.

The egg stage, which is spent under water, generally either attached to some stone or other object in the bed of the stream or wedged in some sub-aqueous crevice, probably lasts some two or three weeks. Eggs of *Deleatidium vernale* incubated under laboratory conditions in tap water, hatched in fifteen days, those of *Coloburiscus humeralis* in eighteen days and those of *Ameletus flavitinctus* in twenty-seven days.

Heymons (21) hatched *Ephemera vulgata* in ten to eleven days, but mentions that, according to Joly, *Polimitarcys* requires six to seven months for incubation.

The water temperature has a marked effect on the time needed for hatching.

The number of eggs laid by different species varies greatly. *Deleatidium vernale* oviposits 600-800, whereas *Oniscigaster distans* is at least ten times as prolific.

The method of attachment and appearance of individual eggs is equally diverse. In some cases, e.g., *Coloburiscus humeralis, Ameletus flavitinctus, Atalophlebia versicolor,* they are fixed to the substratum by means of some attached cement-like substance, in others, e.g., *Deleatidium vernale,* the cement is absent and they are either lodged in some sub-aqueous cranny or anchored to vegetable or mineral matter by means of cables or projections attached to the egg.

Morgan (20) found that all the eggs of the American species she examined were viscid and adhered to the bottom. In many New Zealand species this is not the case, in fact in one or two cases, the eggs appear to be enveloped in some viscid material as they leave the oviducts and this dissolves off in the water as the eggs drop through it.

The shape of the egg is ovoid, sometimes almost a regular oval, sometimes exceedingly irregular. The chorion is usually intricately sculptured, covered with small protuberances and with minute pits: often there are micropylar masses and anchoring strands as in *Coloburiscus humeralis,* some have net-like cushions at four corners, e.g., *Deleatidium sepia.* In others this network surrounds the entire egg as in *Atalophlebia versicolor* and a number of species have anchoring strands, e.g., *Atalophlebia nodularis.* Many seem to be entirely devoid of all attachments, e.g., *Atalophlebia dentata, A. cruentata, Deleatidium lillii,* etc. The anchoring threads are coiled up at first and uncoil in the water: sometimes at the distal end of each thread is an adherent blob. Plates 50-52, Figs. 1-5, show microphotographs of the eggs of some of our species.

The size of an egg is microscopic. The following are the dimensions of the eggs of some New Zealand mayflies:—

Ichthybotus hudsoni, .37 × .19 mm.
Ameletus ornatus, .21 × .11 mm.
Oniscigaster distans, .29 × .16 mm.
Atalophlebia nodularis, .20 × .10 mm.
Deleatidium sepia, .19 × .12 mm.
Deleatidium lillii, .17 × .9 mm.
Coloburiscus humeralis, .20 × .18 mm.
Ameletopsis perscitus, .21 × .15 mm.

The minute larvules which emerge through a longitudinal rent in the egg envelope, though about twice as long as the egg that housed them—for they lay coiled up in it—are generally less than half a millimetre long. They breathe cutaneously, for the tracheae and gills do not make their appearance till after two or three moults. The alimentary tract is incomplete, the mouth-parts are not yet fully formed and the antennae and caudal setae have only a few segments. Both

these latter parts, as well as the thin legs, bear a few bristles. The compound eyes are undeveloped and are smaller than the ocelli.

Every few days (the number varies but is usually between three and ten), the insect moults, becomes darker, more complete and larger until the true nymphal form is attained.

The changes are gradual. A specimen of *Coloburiscus humeralis*, ten days old (Text-Fig. 37) did not appear very different from one newly-hatched. It was .50 mm. long, excluding setae. The outer setae, which were apparently five-segmented and ended in a pair of bristles, were about .30 mm. long, the median one being three-segmented and much shorter. [When newly-hatched, the larvule measures .35 mm. and its outer setae .20 mm.] The antennae, also five-segmented and ending in a pair of bristles, were about half as long as the outer caudal setae. The alimentary tract was complete and in working order, but there were no signs of gills: the late appearance of gills in this species may be due to the fact that it lives in the highly-oxygenated water of rapids and so cutaneous respiration may be practicable for longer than in slower waters. Wiebe (23) found that gill rudiments appeared in *Hexagenia bilineata* after the fourth day, Gros (22) in *Ecdyurus forcipula* after the fifth day, Heymons (21) in *Ephemera vulgata* after four days, and Lestage (10a), in general, from eight to ten days.

Very minute individuals are seldom taken when netting streams for specimens, and I am inclined to the opinion that, in many species, they live slightly below the bed of the stream, often in fine gravel. The early stages of *Oniscigaster* may be found in such situations.

In the nymphal stage, the insect varies considerably in appearance according to species, but the general type is as follows:—It has a small head (except *Ameletopsis*) with well-developed mouth-parts of the biting type and filiform antennae about twice as long as the head. The eyes of male nymphs are each double, consisting of an upper and a lower part and the eyes are set closer together than those of the female, where the eyes are simple. The thoracic segments are well differentiated, but the meta-thorax is welded to the first abdominal segment: after the wingpads are fairly well-grown, they hide the posterior two segments. Attached to each thoracic segment is a well-developed leg, consisting of coxa, trochanter, femur, tibia and tarsus, each composed of a single segment; at the apex of each leg is a curved, acuminate claw.

Towards the end of the nymphal life, wingpads develop on the dorsum of the meso-thorax and meta-thorax.

The abdomen, which sometimes broadens in the middle and always tapers posteriorly, consists of ten segments. Attached latero-posteriorly to each of the anterior seven of these segments is a pair of gills, which are held laterally or dorsally. These gills are the insect's respiratory organs.

In the case of *Ichthybotus* the gills of the first pair and in that of *Oniscigaster* those of the last pair are not visible to the unaided eye, but microscopic investigation shows that they are there.

At the posterior extremity of the abdomen are three caudal setae: in *Coloburiscus*, the median one is vestigial only. In some cases these

setae assist propulsion, in others they appear to be mainly aids to balance.

The nymphal life lasts some months, usually about eleven. Though as yet no New Zealand species has been followed throughout the whole of its life cycle, it is evident that one year is the normal period, though one or two species, e.g., *Ichthybotus hudsoni,* may have a two year life cycle, and a few others, possibly, less than a year. *Deleatidium lillii,* for instance, is found in all stages throughout the year, though it is more numerous in the winged stages in spring and autumn.

Towards the end of its sub-aqueous life, the wing-pads of the insect grow larger and the organs of reproduction develop internally: a full-grown female nymph is already full of eggs. When the time for metamorphosis arrives, the nymph becomes very sluggish and bubbles of air appear below the skin, usually at or near the pronotum.

In the SIPHLONURIDAE, the nymph crawls out of the water on to a stone or boulder at the edge of the bank or sometimes on to a protruding boulder in the middle of the stream: in the other families, the transformation is made very suddenly from the surface of the water.

The skin of the thorax splits longitudinally along the dorsum and the sub-imago emerges, shakes out its folded wings which soon dry, and in a few moments flies away to shelter in some shady spot near the river-bank. Here it stays motionless, unless disturbed, its wings held upright over the dorsum.

Mayflies are the only insects that have two winged stages, though Carpenter in his '*Biology of Insects*' suggests that it was of general occurrence among primitive winged insects in past ages. The preparatory winged period is a short one, lasting about a day in the LEPTOPHLEBIIDAE and usually two days in the other families. In *Oniscigaster,* however, the sub-imaginal stage lasts three days.

The sub-imago differs from the perfect insect only very slightly. The integument is duller, particularly that of the wings. These are generally coloured and bear little hairs along the edges. The fore-legs are shorter, as are the caudal setae. The eyes are duller and not so protuberant, the genital organs are not quite fully-developed and their armature is shorter and stouter.

At the end of this brief stage, the insect moults again and transforms into the imago or perfect insect.

The duration of this period, the ultimate one in the life of a mayfly, is about the same as that of the foregoing stage.

The general form of the imago does not differ very greatly from that of the nymph, but the head is smaller, the eyes more brilliant, the antennae shorter, the mouth-parts atrophied and non-functional—as is also the alimentary tract, which has now an aerostatic function and is apparently closed posteriorly. The gills have disappeared, the insect breathing in the normal manner through stigmata. The body is slimmer and glistening, the legs much thinner and longer, the tarsus being now four or five-segmented and armed with two claws apically, which are sometimes alike, sometimes dissimilar. The fore-legs of the male are exceedingly long, their use being accessory to the genital act. The caudal setae are usually longer than those of the nymph and sometimes the median seta is vestigial only in the adult

but fully-developed in the nymph. In this connection, I should like to point out that out mayflies would seem to disprove the theory of Joly, apparently accepted by Vayssière (9), that the number of tails in the newly-hatched larvule and in the winged stages is the same, for in *Ameletus flavitinctus* specimens just out of the egg have three caudal setae of about equal length, whereas in the imago, the median seta is vestigial, as it is in the case of all the New Zealand species of the family SIPHLONURIDAE. The setae of the imagines of these families are never heavily fringed with hairs as they sometimes are in the nymphal stages.

The genitalia visible externally consist, in the case of the male, of accessories in the shape of a pair of three or four-segmented, incurved claspers, attached ventrally to the posterior of the abdomen, which are curved round the abdomen of the female during copulation: interior to these are the paired penes, the distal parts of which are bent upwards and bear ventrally-placed orifices near the apex. In the accompanying illustrations, the tenth tergite has been omitted for the sake of clearness.

The two oviducts of the female terminate each at a latero-ventral opening between the seventh and eighth segments; the openings are covered by a thickly-chitinised ventral flap.

The wings are fragile; they are triangular and furrowed with numerous veins and cross-veins.

The hindwings are much smaller than the forewings: in the LEPTOPHLEBIIDAE they are very minute. So far, no species has been found in this country without hindwings.

The wings of the female are usually larger than those of the male: *Deleatidium vernale* is exceptional, in that the reverse is the case.

A curious and somewhat confusing circumstance—and one that I have not seen mentioned elsewhere—is that the same species of mayfly may often be found to vary very considerably in dimensions not only in different districts but in the same district at different times, and, in this connection, I have noticed that flies at the end of their season are often smaller than the normal size.

An excellent diagram of a mayfly's wing, showing the different systems of venation, variously charactered, is given by Chopra (29).

NOTES ON TERMINOLOGY.

In the following descriptions, I use certain terms, which may not be in accord with those applied to similar parts of mayfly nymphs by writers in other countries.

To avoid any possible misunderstanding, the terms, together with the sense in which they are used, are as follows:

Prostheca applied to the small finger-like process on the mandible, proximal to the inner canine. This term is used by Lestage and Imms. The prostheca is the *endopodite* of Eaton and the *lacinia* of American writers.

Superlinguae applied to the lateral lobes of the Hypopharynx. Imms uses this term. American writers use the expression *lateral lobes*, Lestage *pièces laterales* and Eaton calls them *paraglossae*.

Glossae and *Paraglossae* applied to the internal and external paired lobes, which occur on the labium and are appended anteriorly to the mentum.

These terms are used by Imms and also by American writers on Mayfly nymphs. Lestage, however, calls them *lobes internes* and *lobes externes* and Eaton refers to them as the lobes of the *labium.*

Legs.—The terms *anterior* and *posterior, dorsal* and *ventral* are used in the same sense as they are used anatomically, irrespective of the actual position of the portion of the limb visible.

Thus, the femur, tibia and tarsus of the limb of a mayfly nymph may be held with the *anterior* surfaces turned over so that they appear *dorsal*—as is very frequently the case—and may be figured so; nevertheless these surfaces will be described as *anterior surfaces;* the real *dorsal* surface will be described as such in the text, but in the case instanced will appear in the specimen—and probably the illustrations—as turned over so that it faces *posteriorly.*

CLASSIFICATION.

The Classification adopted has been arranged so as to conform with that of Tillyard, the key to families (adults) is taken from his book (7).

The generic key (adults) has been adapted from Hutton (2) in the light of later knowledge.

As the keys to nymphal characters of both Needham (8) and (9) and Lestage (10) and (10a) are not adaptable to New Zealand families and genera, I have designed one more suited to local conditions.

KEY TO FAMILIES AND GENERA OF N.Z. EPHEMEROPTERA.

Adults.

A. Forewing with tornus at from 1/3 to 2/5 of wing length from base, with Cu 1 ending just beyond it and being sigmoidally curved (Text-Fig. 14).	EPHEMERIDAE
Median caudal seta abortive in the male, subequal to the outer ones in the female	*Ichthybotus* Eaton
B. Forewing with tornus at from 2/5 to nearly ½ the length of the wing from base, the nearly straight Cu 1 ending up just beyond it and having a descending series of pectinate branches: Cu 2 curved concavely to Cu 1 (Text-Fig. 15)	SIPHLONURIDAE
1. *Hind tarsi shorter than tibiae*—	
(*a*). One tarsal claw sharp, the other blunt: Cross-veins in the ptero-stigmatic region reticulate.	
(*i*) Humeral angle of hindwing sharp	*Coloburiscus* Eaton
(*ii*) Humeral angle gently rounded	*Ameletopsis* n. g.
(*b*). Both tarsal claws sharp and hooked: Cross-veins in the ptero-stigmatic region simple.	
Femora with heavy dark median bar	*Ameletus* Eaton
2. *Hind tarsi longer than tibiae*	*Oniscigaster* McLachlan
C. Forewing with tornus at not more than ½ of wing length from base. Cu 2 sigmoidally curved, ending not far short of tornus (Text-Fig. 16)	LEPTOPHLEBIIDAE
1. *Tarsal claws alike, narrow and hooked at tip* . .	*Atalophlebia* Eaton
2. *Tarsal claws unlike, one narrow, hooked and pointed at tip, the other broad and blunt*	*Deleatidium* Eaton

Nymphs.

A. Mandibles with tusklike extension, protruding in front of head (Text-Fig. 9)	EPHEMERIDAE
With six pairs of gills, visible to the unaided eye: these are feathery and lie on the dorsum (on 2nd to 7th abdominal segments) (Text-Fig. 1) (NOTE: There is another pair on the first abdominal segment, but it is microscopic).	*Ichthybotus* Eaton
B. Mandibles short, not extending in front of head—	
I. Caudal setae densely haired throughout their length.* Tarsal claws not toothed underneath† (Text-Fig. 12)	SIPHLONURIDAE
1. *Gills held upright over the dorsum*—	
(i) Gills forked and with numerous spines (Text-Fig. 3) .. .. (Median caudal seta very short).	*Coloburiscus* Eaton
(ii) Gills lamellate and recumbent on dorsum (Text-Fig. 2) .... (7th pair microscopic).	*Oniscigaster* McLachlan
2. *Gills held extended laterally*: *lamellate* (Text-Figs. 4 and 5).	
(i) Head small (Text-Fig. 10): palps three-jointed: outer setae haired on both sides	*Ameletus* Eaton
(ii) Head large and skull-like (Text-Fig. 11): palps many-jointed: outer setae haired on both sides	*Ameletopsis* n. g.
II. Caudal setae with whorls of a few thin, short hairs at joints; Tarsal claws toothed underneath (Text-Fig. 13)	LEPTOPHLEBIIDAE
1. *Gills double* (Text-Fig. 8)	*Atalophlebia* Eaton and sub-genus *Atalophlebiodes* of the genus *Deleatidium*
2. *Gills single* (Text-Figs. 6 and 7)	remainder of genus *Deleatidium* Eaton

* Except *Coloburiscus.*

† The claws of *Ameletus ornatus* have a number of very minute serrations underneath, but these are very much smaller than those of a *Leptophlebid* claw.

Family EPHEMERIDAE.

This family is identical with Lestage's (10) family EPHEMERIDAE and Needham's (8) sub-family EPHEMERINAE. The nymphs are of the digging type and live in burrows made in sand or sandy clay in the beds or submerged parts of the banks of streams.

In New Zealand, the family is represented by only one genus, *Ichthybotus* Eaton. The nymph very greatly resembles the type *Ephemera* of Eaton (4), having the characteristic digging tusk projecting in front of the head, the modified fossorial forelegs and the double feathery gills, which are held over the dorsum and keep aerated water circulating in the burrow.

It differs from *Ephemera* in that the head does not narrow anteriorly, the tusks are shorter, broader and curve *inwards* not outwards,

apically: the clypeus is not deeply incurved anteriorly: the setae are shorter in proportion to the length of body and the labrum is wider in proportion to its length and has concave lateral margins.

The adult shows differences from *Ephemera* in the caudal setae, the claws of the male fore-legs and the genitalia.

There are two species, *I. hudsoni* (McLachlan) and *I. bicolor* Tillyard.

Genus ICHTHYBOTUS Eaton (1899).

Adult.—"A genus of the Sectional Type of Ephemera, resembling *Pentagenia* in style of wing-neuration, and in having the median caudal seta abortive in the male imago, but either not much shorter than or sub-equal in length to the outer setae in the female. Legs as in *Ephemera*, excepting the claws of the fore-tarsus of the male, the outer claw being hooked and the inner obtuse. Distinguished from the other genera of this Sectional Type by the male genital forceps, resembling in pattern those of a *Siphlurus* (cf. *S. lacustris*). The forceps-basis subquadrate with the posterior angles obliquely truncate for the insertion of the limbs, the first joint in which is shorter than the basis. The name in Greek means *fed on fish.*" (Eaton).

Nymph.—Mandibles prolonged in front of the head in the form of tusks, which curve inwards apically. Maxillary palp of three segments. Labial palp of two segments. Antennae long, filiform. Body elongated, tapering posteriorly, convex dorsally. Legs robust, densely haired: order of length, 3, 1, 2: anterior pair adapted for digging: claws untoothed. Six pairs of double feathery gills held upright over dorsum on the second to seventh abdominal segments and one minute, rudimentary pair, each gill of which is in the form of a bifid lash, on the first abdominal segment. Caudal setae short, densely haired on both sides: median seta slightly longer than the others.

Ichthybotus hudsoni (Eaton).

IMAGO.

Length (excl. setae)—male, 19-21 mm.; female, 20-22 mm.

Head—male, fawn with brown markings; female, yellow with brown markings. Eyes of female olive; of male, upper part reddish-brown, lower part olive. Ocelli brown.

Thorax.—Prothorax fawn: meso- and metathorax light-brown with yellow (female) and fawn (male) markings.

Abdomen.—Dorsum of male, dull reddish-brown; of female, bright orange-brown and broader than that of the male. There is a small tooth on each pleuron, two-thirds of the way towards the posterior edge: on the eighth segment it is absent, on the ninth and tenth it is more acuminate and almost at the latero-posterior corner.

Venter paler; on each segment is a reddish-brown circumflex-like mark placed medio-anteriorly and a pair of dots posteriorly.

Penes yellow, "bifid with thin or flattened lobes of equal width: concave beneath, truncate at the tips and divergent." (Eaton). Claspers (Plate 4) yellow, becoming greyish distally.

Caudal setae fawn, becoming lighter distally; black-ringed at joinings: outer ones, male, 23 mm.; female, 20 mm.; median one, male, 1 mm.; female, 19 mm.

Legs (Text-Fig. 35).—Femora: anterior pair light yellow, tinged with olive; other pairs light yellow; Tibiae, light yellow. Tarsi, light-yellow, tinged apically with dull-olive; five-segmented in male fore-leg, apparently four-segmented in female foreleg and in all hindlegs. Claws dissimilar.

Wings (Pl. 53, Fig. 7).—Expansion of male, 20 mm.; female, 22 mm. Marginal and sub-marginal areas burnt-umber: the rest of the wing-surface is hyaline in the male and light yellowish-green in the female. Neuration black but brown at wing-base.

Sub-Imago (Pl. 53, Fig 8).

Wings.—Surface pearly in the male, lemon-yellow in the female: marginal and sub-marginal areas raw-umber, except at wing-base, where it is yellow. Both fore- and hindwings have two dusky zig-zag bands running transversely, but in some specimens, these bands are absent. Cross-veins very numerous, especially near the wing-margin.

Duration of sub-imaginal stage, about two days.

Nymph.

This nymph (Pl. 52, Fig. 6) belongs to the only genus of burrowing mayflies found in New Zealand. The genus consists of two species, *I. bicolor,* discovered a few years ago by Tillyard (6), who described the imago and sub-imago, and *I. hudsoni,* described by McLachlan (11) in 1894, Eaton (5) in 1899, and Hudson (1) in 1904.

The nymph of the former species has not yet been described, that of the latter only briefly and with insufficient detail to distinguish it from nymphs of this family in other countries: for this reason, it is described more fully below.

Incidentally, the opportunity is taken of pointing out that gills are present on the first *seven* abdominal segments, not on the first *six*, previous describers having apparently mistaken the second abdominal segment for the first, which is fused with the metathorax and bears very minute, reduced gills.

Moreover, the writer would like to submit the opinion that Lestage (10), in describing the family Ephemeridae, was mistaken in regarding the mandibular tusk as a canine, for both outer and inner canines are present in addition to the tusk in our species, as they are indeed in American [see Murphy (12), Text-Fig. 1, p. 16] and European species [Eaton (4) Plates], and Needham (13) Plates.

This nymph burrows in the sandy or muddy banks of streams, below water level.

It swims with dorso-ventral, undulating movements of the body.

If disinterred from its tunnel, it will bury itself in the nearest sandy patch, burrowing with its forelegs and mandibular tusks and digging itself in with remarkable rapidity.

When about to transform, nymphs in the writer's aquarium left their burrows and floated for some time, unmoving on the surface of the water, rarely agitating their gills.

A quantity of air was noted under the skin of the thorax and of the anterior part of the abdomen.

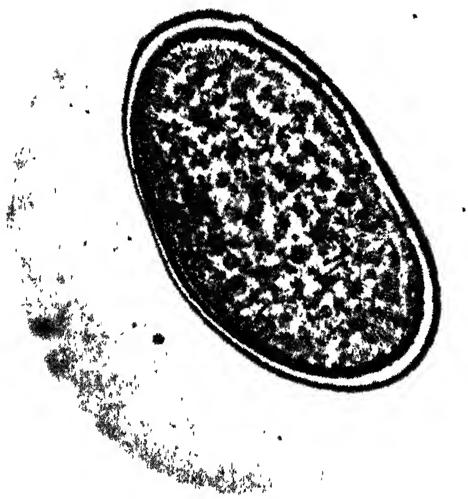


Fig. 1.—Egg of *Ichthybotus hudsoni*. × 170.

Fig. 2.—Eggs of *Oniscigaster distans*. × 170.

Face p. 280.

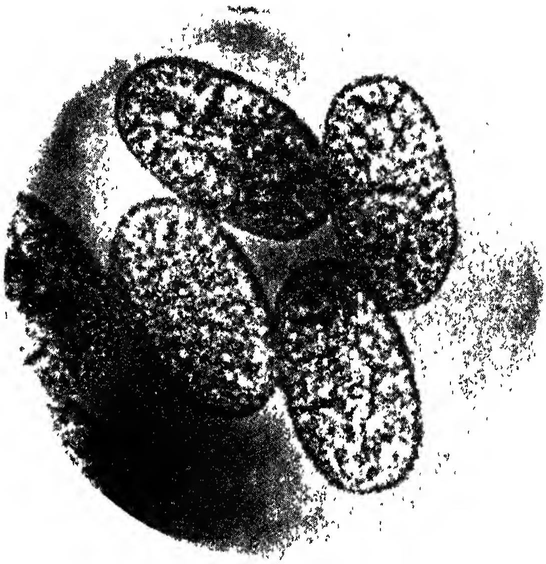


FIG. 3.—Eggs of *Ameletus ornatus*. × 170.

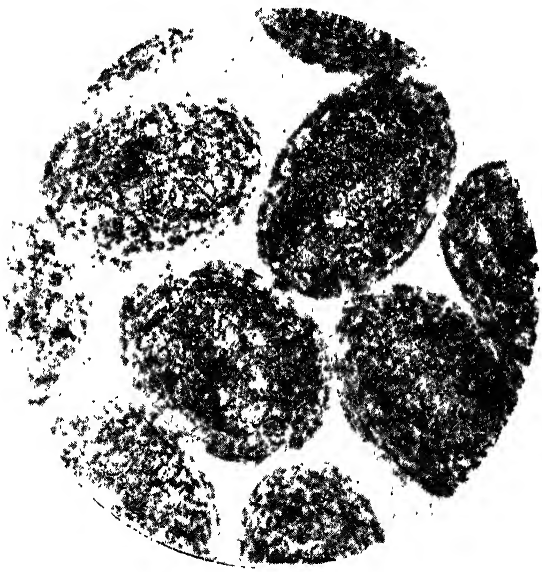


FIG. 4.—Eggs of *Ameletopsis perscitus*. × 170.

Fig. 5.—Eggs of *Atalophlebia cruentata.* × 170.

Fig. 6.—Nymph of *Ichthybotus hudsoni.*

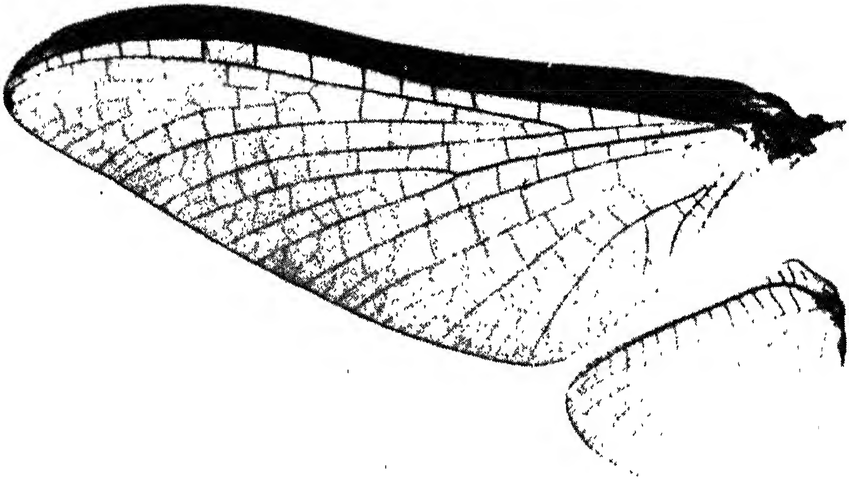


FIG. 7.—*Ichthybotus hudsoni*: ♂ Imago.

FIG. 8.—*Ichthybotus hudsoni*: Female Sub-imago, ca. × 2.

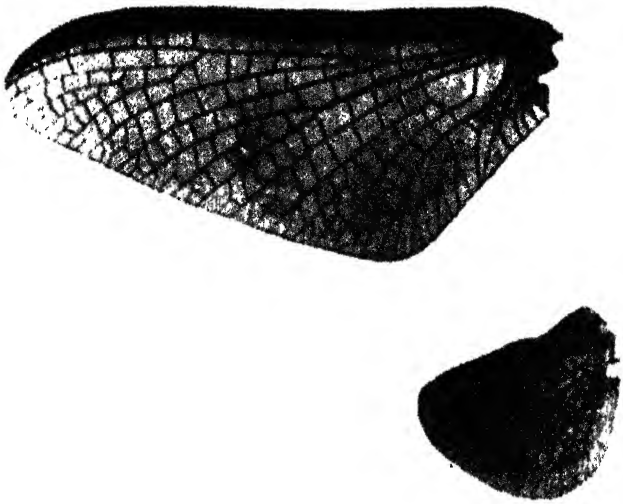


Fig. 9.—*Ichthybotus bicolor*: ♂ *Imago*. × 4.

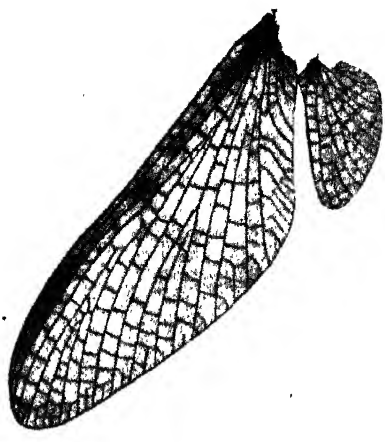


Fig. 10.—*Coloburiscus humeralis*: ♂ Sub-imago. × 5.

FIG. 12.—*Oniscigaster intermedius*: ♀ Imago, dorsal view, ca. × 3.

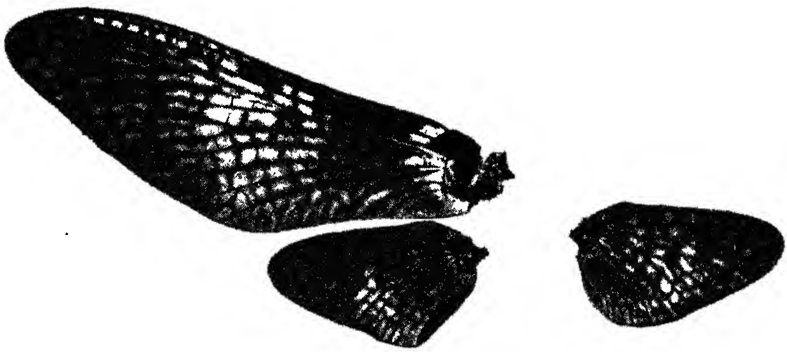


FIG. 13.—*Oniscigaster intermedius*: ♂ Sub-imago. × 5.

FIG. 14.—Nymph of *Oniscigaster intermedius*. × 2½.

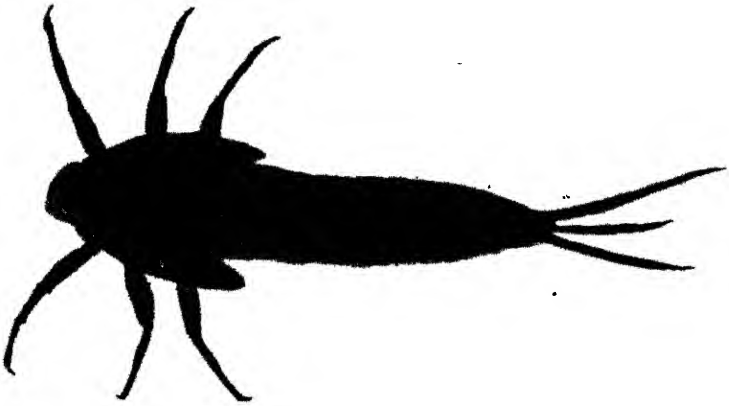


FIG. 15.—Nymph of *Ameletus ornatus*. × 5.

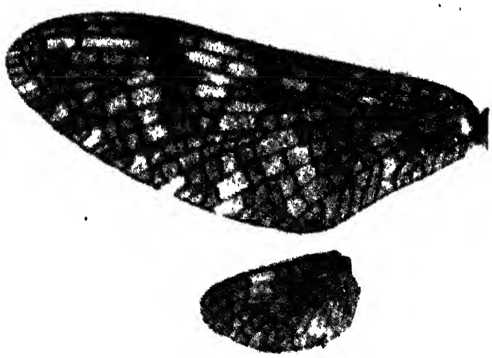


FIG. 16.—Wings of *Ameletus ornatus*: ♀ Imago. × 5.

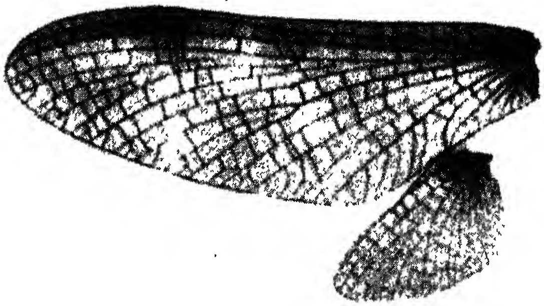


FIG. 17.—*Ameletus flavitinctus*: ♀ Imago. × 5.

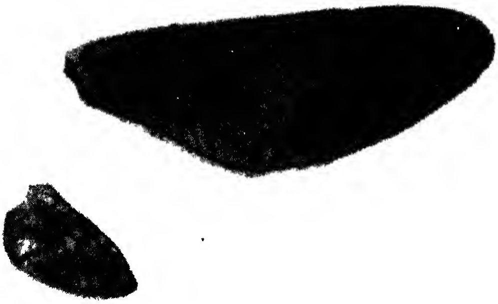


FIG. 18.—*Ameletus flavitinctus*: ♂ Sub-imago. × 5.

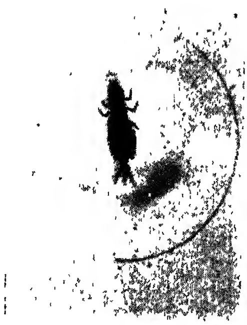


FIG. 19.—Nymph of *Ameletopsis perscitus*, ca. ½ natural size.

FIG. 20.—Gills of *Ameletopsis perscitus* (much enlarged).

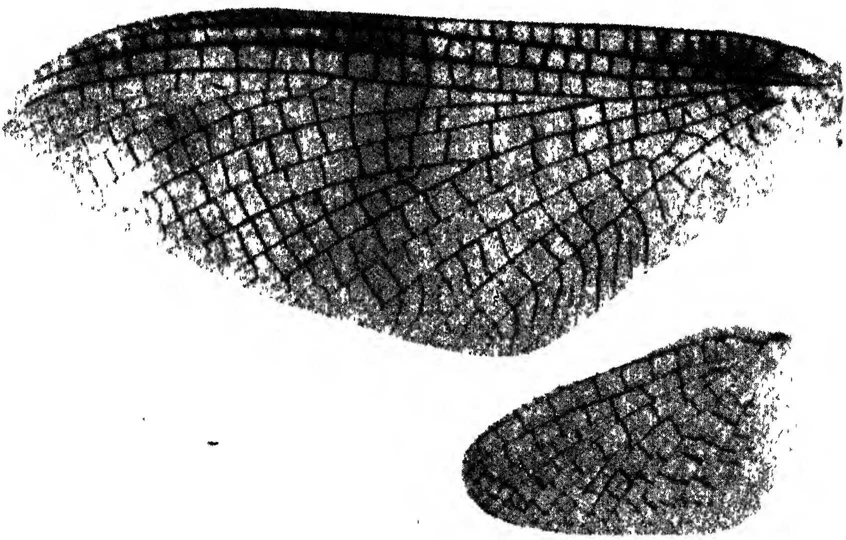
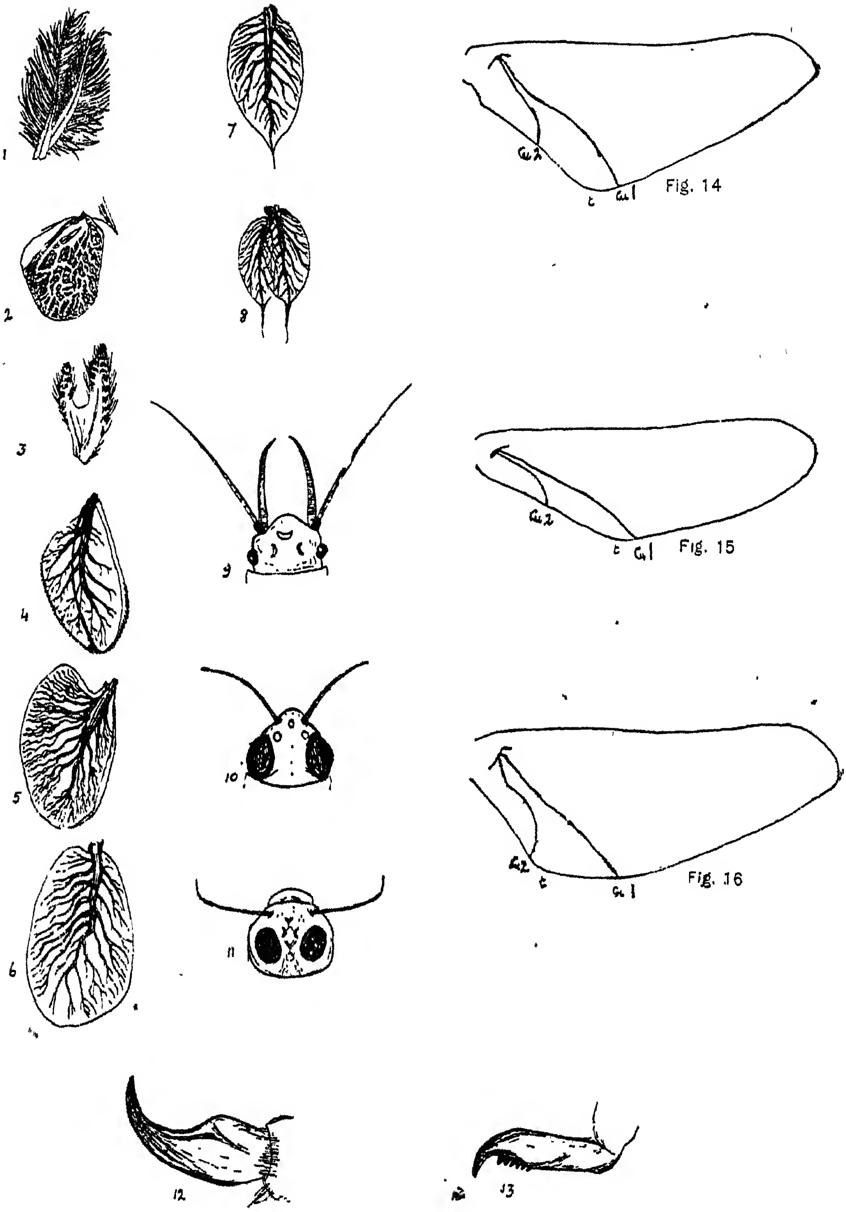


FIG. 21.—*Ameletopsis perscitus*: ♀ Imago. $\times 6\frac{1}{2}$.



FIGS. 1 to 13.—Key to Families and Genera.—*Nymphs.*
FIGS. 14 to 16.—Key to Families and Genera.—*Adults.*

T

The actual metamorphosis, which occurred as usual through a longitudinal rent in the dorsum of the thorax, was extraordinarily swift, in marked contrast to the long time (sometimes hours) spent on the surface waiting for the change.

This protracted wait may have been due to the unnaturally still condition of the water present in the aquarium.

The winged stages appear in December, January and February, but as nymphs of various sizes are seen at this time, it is likely that this fly has a two-year or even possibly a three-year life-cycle.

Description of Nymph:

Length (including setae).—About four centimetres.

Head (Text-Fig. 27).—Reddish-brown; *Epicranium* convexly arched. There are patches of hair at the postero-lateral angles and also—accompanied by areas of small spines—on the lateral edges between the eyes and the antennal pits and at the latero-anterior edges of the clypeus.

Eyes.—Dark brown, and of moderate size.

Antennae.—Long, filiform, becoming slenderer apically, with a whorl of fine short hairs at joints, emerging from a pair of truncated prominences.

Mouthparts—Labrum (Text-Fig. 31).—Length, about three-fifths of width. The anterior and lateral edges are heavily chitinised. The general shape of the anterior edge is convex, but there is a gentle median concavity. The anterior corners are rounded and the lateral

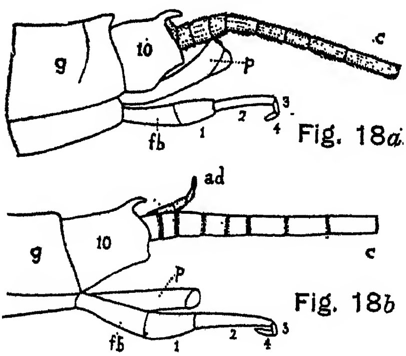


Fig. 18*a*.

Fig. 18*b*

Fig. 19*a*.

Fig. 19*b*

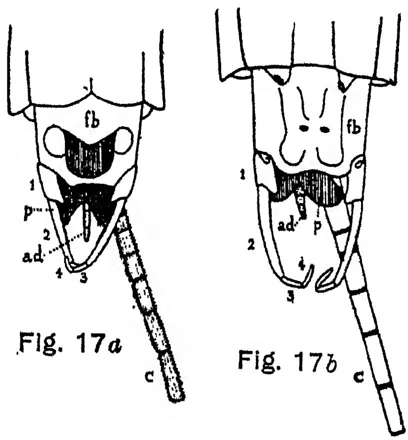


Fig. 17*a*

Fig. 17*b*

FIG. 17.—Ventral view of male appendages in the genus *Ichthybotus* Eaton: *a*, in *I. bicolor* n. sp.; *b*, in *I. hudsoni* McL. × 14. 1, 2, 3, 4, the four segments of the forceps; 9, 10, the last two abdominal segments; *ad*, appendix dorsalis; c, cercus (the right cercus is omitted); *fb*, forceps basis; *p*, penis.

FIG. 18.—Left lateral view of male appendages in the genus *Ichthybotus* Eaton: *a*, in *I. bicolor* n. sp.; *b*, in *I. hudsoni* McL. × 14. Right cercus and right forceps omitted. (For lettering see Fig. 3).

FIG. 19.—Outline of ventral valve in the female of *a*, *Ichthybotus bicolor* n. sp., and *b*, *I. hudsoni* McL. × 14.

(*From Tillyard*).

edges slope inwards posteriorly, more sharply so at a point about two-thirds of the way from the anterior edge. The postero-lateral corners are obtusely-angled. The surfaces and edges (except the posterior edge) are densely covered with long hair.

Hypopharynx (Text-Fig. 24).—Superlinguae rounded anteriorly and densely haired at the edges, except the exterior ones. Median lobe with concave anterior edge haired and a number of spines on anterior portion of surface.

Maxilla (Text-Fig. 30).—Palp three-jointed: the distal joint is the longest, the second one the shortest: all are covered with long hairs. The galea-lacinia is very small, being slightly shorter and much narrower than the basal joint of the palp. It is chitinised apically. On the interior edge is a fringe of spinose hairs, and anteriorly are a number of long spines of varying thickness. There is a row of long hairs, rooted medianly on the surface of the anterior portion and lying anteriorly-interiorly.

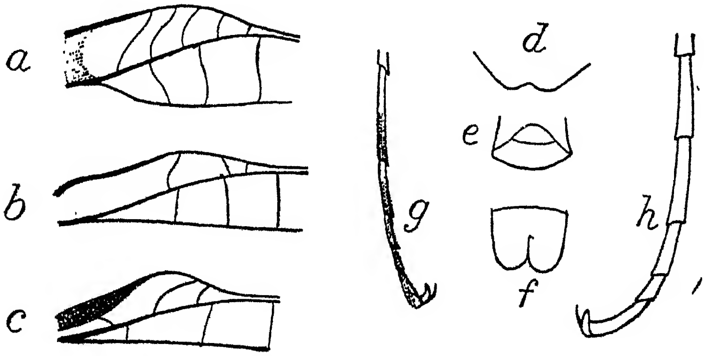


FIG. 20.—Details of the morphology of the female imago in the three New Zealand species of *Ameletus*: *a*, *A. perscitus* Eaton, humeral angle of hindwing; *b*, the same in *A. ornatus* Eaton; *c*, the same in *A. flavitinctus* n. sp.; *d*, *A. perscitus* Eaton, ventral valve; *e*, the same in *A. ornatus* Eaton; *f*, the same in *A. flavitinctus* n. sp.; *g*, *A. flavitinctus* n. sp.; hind tarsus; *h*, *A. ornatus* Eaton, hind tarsus. All figures × 14.

(*From Tillyard*).

See Vol. 54, *Trans. N.Z. Inst.*

Mandible (Text-Fig. 29).—The mandible is prolonged anteriorly into an enormous tusk, which is curved slightly inwards and bluntly pointed at the apex; it is held by the nymph in front of the head. This tusk is densely haired along its exterior edge and along here, too, are a number of short, thick spines: it is also haired and spined upon its surface—mainly the exterior-anterior portion. At the posterior-interior corner of the tusk and at the base of the mandible are irregularly-shaped, chitinised prominences (Text-Fig. 29, p^1, p^2). Outer and inner canines (c), each with three crenate teeth (in some specimens the third tooth appears double, making 4 teeth). Prostheca (p) long, slender and lightly-chitinised. Prostheeal brush very small. Molar surface (m) with eight or nine parallel, serrated ridges.

Labium (Text-Fig. 28).—Palps two-jointed. Basal palp narrow-

ing somewhat anteriorly, with a fringe of long hair near the interior edge and at the base. (The left-hand palp, shown in figure, is distorted). Distal joint falcate with a fringe of long hair round the edges. Placed distally are a number of basiconic sensillae. Paraglossae triangular with rounded angles, the apex placed anteriorly: they are densely covered throughout with spinose hairs.

Glossae are somewhat similar in shape to the paraglossae; they are as long, but not so wide: they are also covered all over with spinose hairs. (The glossae are shown somewhat displaced—in particular the right-hand one—in the labium figured).

Thorax.—Dark-brown, with a thin light median line, running anterior-posteriorly: fringed with hair laterally: slightly wider than the abdomen.

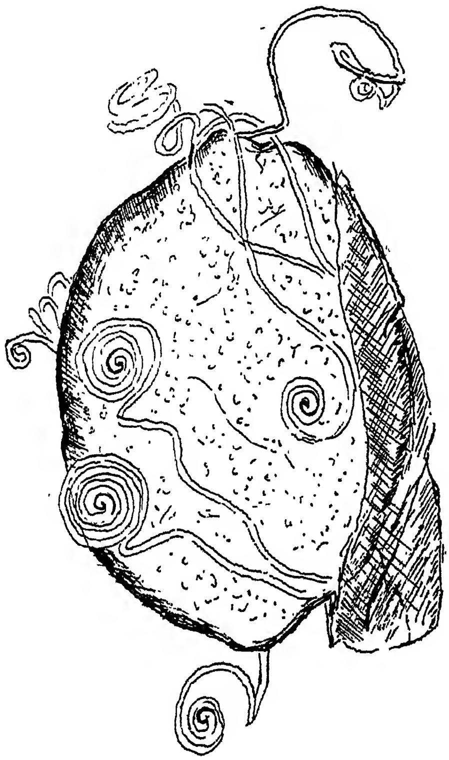


FIG. 21.

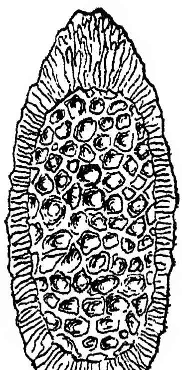


FIG. 22.

FIG. 21.—*Coloburiscus humeralis*: Egg. × 320.
FIG. 22.—*Atalophlebia versicolor*: Egg. × 320.

Prothorax about two-thirds as wide as it is long: mesothorax as long as the prothorax: metathorax shorter than either of the other thoracic segments.

Wingpads.—Dark-brown, and of medium size.

Abdomen.—Dingy yellowish-white: narrowing posteriorly: first segment fused with metathorax: segments lengthening posteriorly as

far as the eigthth segment: segment nine, though almost as long as segment 8, is noticeably narrower and the tenth segment is much narrower and only half as long as the ninth. Median tufts of hair occur dorsally and hairs project laterally from the pleura.

Setae.—Length, 6.5 to 7 mm.; median one a shade the longest. They are thickly fringed with long hairs on both sides. These hairs

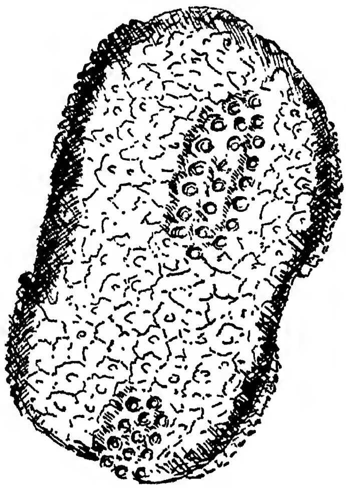
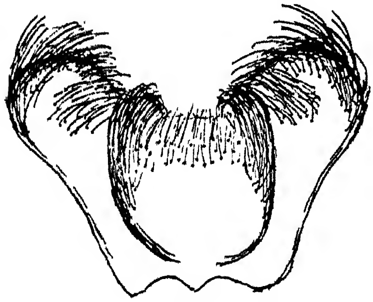


FIG. 23.—Egg of *Deleatidium (Atalophlebioides) sepia.* × 320.

become shorter and sparser distally till in the last few segments they are only represented by a whorl of short, fine hairs at the joints.

Gills.—There is a pair of gills present on each of the first seven abdominal segments. The gills of the first pair (Text-Fig. 25) are vestigial only and are each in the form of a bifid lash: careful scrutiny with a microscope is necessary in order to find them: they are near the latero-posterior edges. The six pairs present on the second

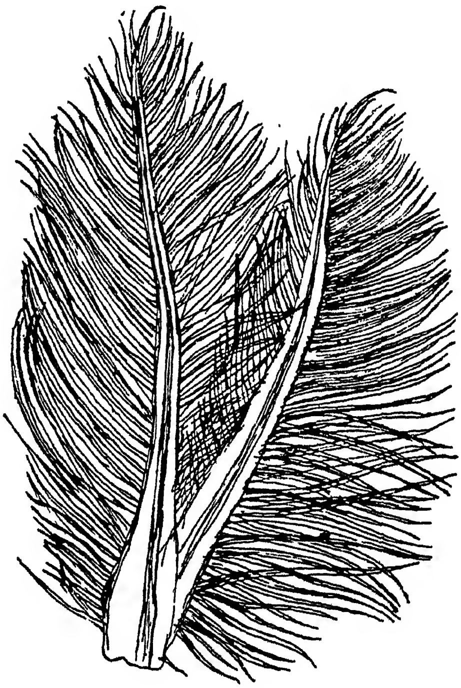


Nymph of *Ichthybotus hudsoni.*
FIG. 24.—Hypopharynx. × 60.

Nymph of *Ichthybotus hudsoni.*
FIG. 25.—Gills of first abdominal segment. × 24.

to seventh abdominal segments are held recumbent on the dorsum. Each gill (Text-Fig. 26) is double and resembles a pair of feathers with rhachides swelling out basally, and long, thin barbs, diminishing in length towards the apex. These 'barbs,' the gill filaments, are minutely serrated on each edge and from each serration, a small spine projects forwards and outwards.

Each filament contains a tracheal branch running through the middle of it.



Nymph of *Ichthybotus hudsoni*.
FIG. 26.—Gills of second abdominal segment. × 24.

Legs (Text-Fig. 34).—Dissimilar: in each leg the femur is shorter than the tibia and longer than the tarsus. The legs of the third pair are the longest; those of the middle pair are the shortest.

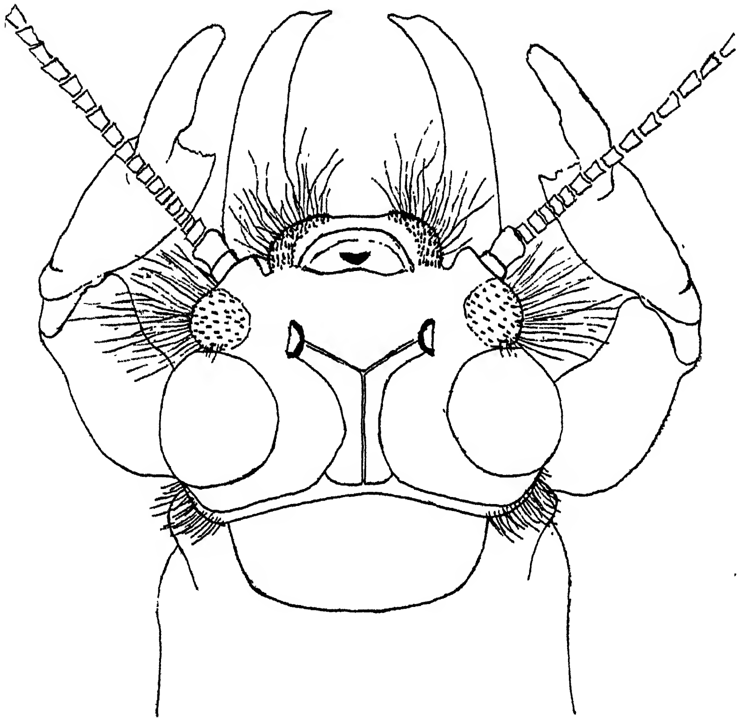
Anterior pair.—*Femora* greatly dilated, ovoid, covered with long hair and studded at the ventral and dorsal edges with a number of short, stout spines.

Tibiae dilated distally, with a V-shaped depression in the distal margin; the ventral arm of the V, which is equipped with an extra row of close-set spines at right angles to the margins, projects sharply and is probably an aid in digging. The greater part of the surfaces and the edges are thickly set with short, stout spines. Long hairs occur on the margins and a few on the surface; there are a few feathered hairs (Text-Fig. 32) on the distal margin in the bay of the V.

Tarsi slightly incurved: there is a row of short, stout spines near the ventral edge, and a fringe of long hairs on the dorsal edge, a few on the ventral one and some scattered over the surface: short feathered hairs occur on the basal part of the ventral edges.

Middle pair.—*Femora* ovoid, dilated, smaller than those of the first pair: covered with long hair, but without spines.

Tibiae becoming wider distally, but not markedly dilated as in those of the anterior pair: distal margin of normal contour: covered



Nymph of *Ichthybotus hudsoni.*
FIG. 27.—Head (dorsal view). × 24.

with long hairs; there are a number of short, thick spines on the distal half of the surface and along the dorsal and distal edges. The ventral part of the distal margin is—as in the first pair of legs—a veritable ' chevaux-de-frise '-like structure.

Tarsi very slightly incurved; fringes of hair arise on the dorsal and ventral edges and a few shorter hairs on the anterior surface. A few short feathered hairs occur distally-ventrally on the tibiae and tarsi.

Posterior pair.—*Femora* ovoid, dilated, longer than those of the other two pairs. They are covered with long hair: along the ventral margin are a number of rows of short feathered hairs.

Tibiae similar in shape to those of the second pair, but longer: covered with long hairs on the edges, and in among these, on the ven-

Fig. 30

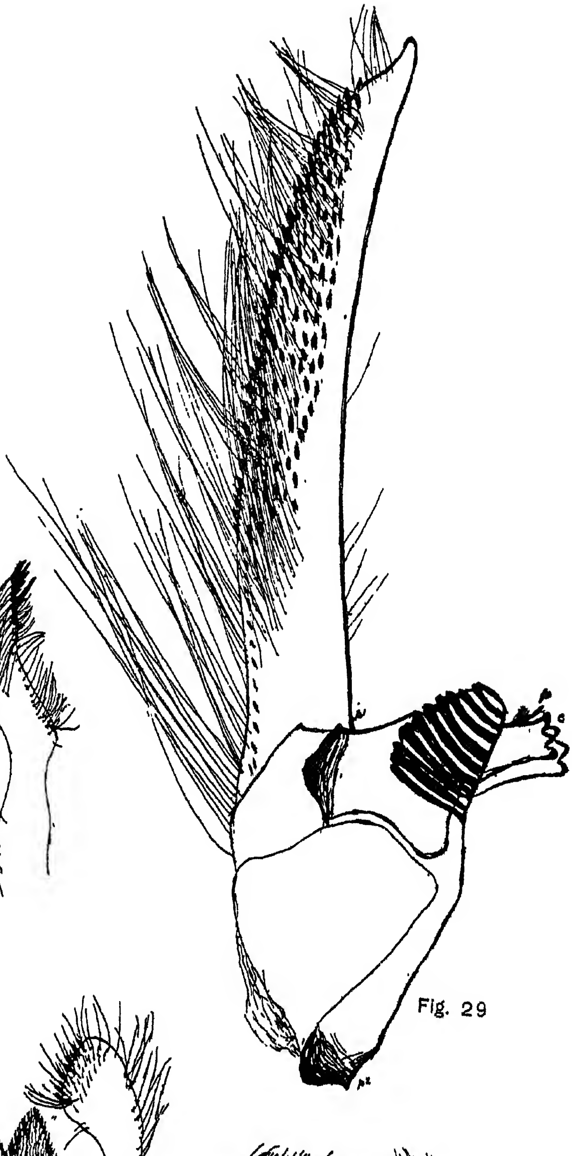


Fig. 29

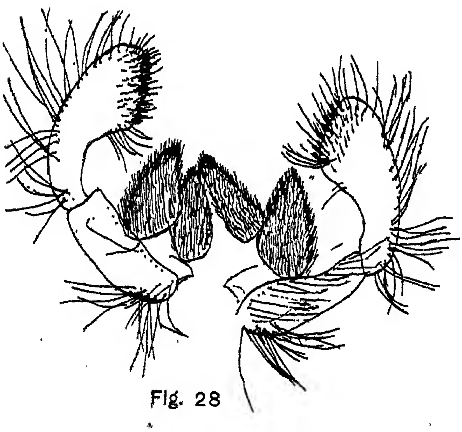


Fig. 28

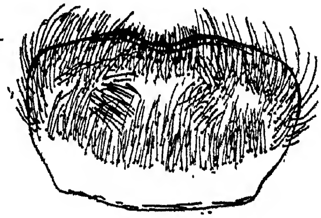


Fig. 31

Nymph of *Ichthybotus hudsoni*.

Fig. 28.—Labium. × 60.
Fig. 29.—Mandible. × 60.
Fig. 30.—Maxilla. × 60.
Fig. 31.—Labrum. × 60.

tral margin, are a number of the short feathered hairs. On the distal margin, these peculiar hairs replace, for the most part, the spines which are found in the same position on the other legs; there are, however, a few stout spines, notably one at each end of the distal margin, the one at the ventral end being especially prominent and projecting forwards and outwards.

Tarsi slightly incurved, with a fringe of long hairs on the ventral and dorsal margins and a few on the surface. Feathered hairs occur on the distal-ventral portion near the edges; from the ventral edge, near the apex, a thick formidable spine projects forwards and outwards.

Claws (Text-Fig. 33) alike in each leg: curved and hooked at tips: not toothed underneath: dark brown. They become progressively more sharply-pointed and more acuminate posteriorly, those of the last pair (illustrated) being very sharply-pointed, the anterior ones blunt—possibly through being used for digging.

N.B.—The feathered hairs (one is figured Text-Fig. 32) which occur on certain parts of the legs of this nymph are extremely curious.

They have been noticed by the writer on only one other mayfly nymph, *Atalophlebia cruentata* (Hudson), an entirely unrelated species, which is described later.

What is still more curious is the fact that in the case of *A. cruentata*, these hairs appear on the anterior pair of legs only.

Ichthybotus bicolor Tillyard.

"IMAGO, male.

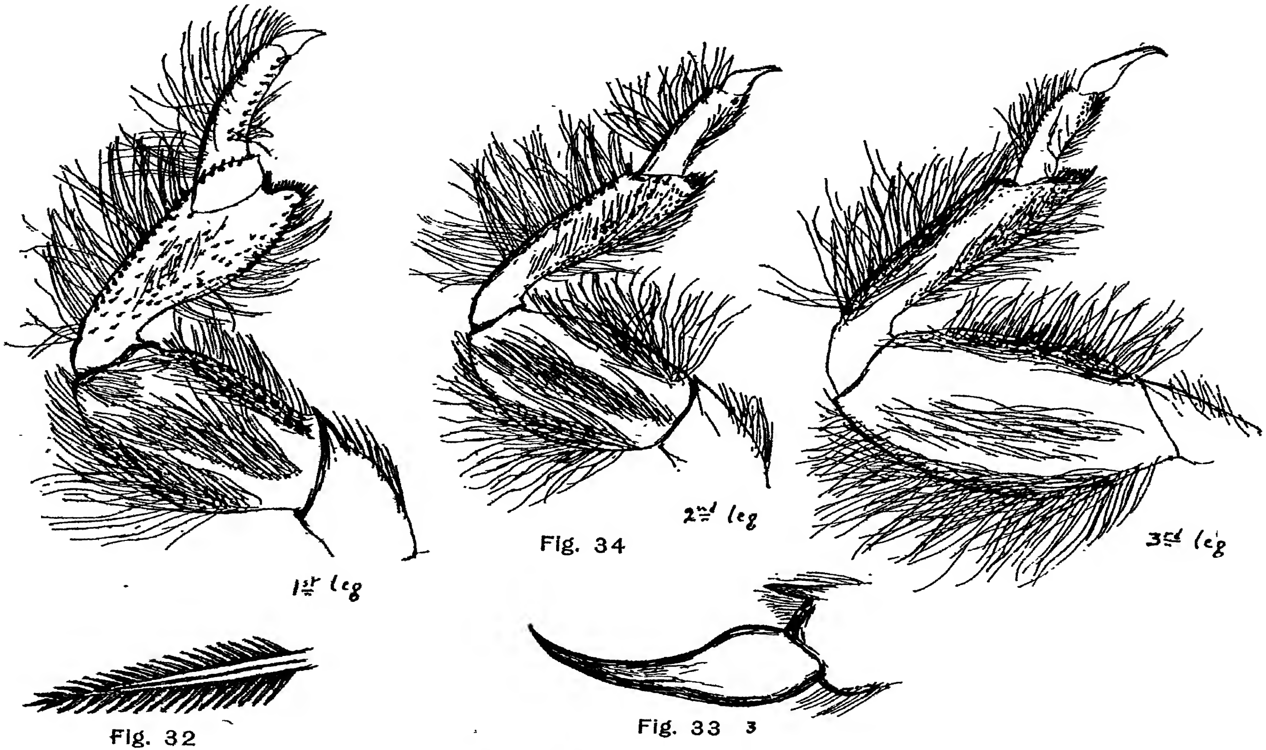
Total length, 19 mm.; forewing (Plate 54, Fig. 9), 16 mm.; hindwing, 6 mm.; expanse, 33 mm.

Head, deep chocolate-brown; eyes, blackish.

Thorax, deep chocolate-brown; legs the same colour, except coxae and the bases of the femora, which are paler; foreleg, 10.5 mm. long.

Abdomen, deep chocolate-brown, faintly mottled with somewhat paler brown; in shape slender subcylindrical, slightly narrowed at 5-7, broadening again at 8-9; 9 much wider than 10, broader apically than basally. Cerci, 23 mm. long, dark chocolate-brown, strongly formed, slightly hairy, the segments cylindrical with narrow black basal rings. Appendix dorsalis vestigial, 1 mm. long, with few segments. Appendages of the same type as in *I. hudsoni* McL., but with the following differences: forceps basis slightly shorter and cut off obliquely on either side of its posterior margin, which, between the bases of the forceps, is cut straight off, not double-curved as in *I. hudsoni*, McL. but more sharply angulated apically on the inner side; segment 2 very long (but not so long as in *I. hudsoni* McL.), narrower, and with a row of minute hairs along the basal two-thirds of the inner margin; segments 3-4 very short, sub-equal. Penis more prominently lobed than on *I. hudsoni* McL., each lobe carrying a set of minute stiff hairs. Cerci 23 mm. long, dark chocolate-brown, strongly formed, slightly hairy, the segments cylindrical with narrow black basal rings; those of *I. hudsoni* McL. are quite hairless, yellowish-brown or orange-brown, with broad dark basal rings. Appendix dorsalis vestigial 1 mm. long, with few segments.

In order that a careful comparison may be made between the appendages of the males of the two species, I have figured them both ventrally in Text-Fig. 17, and laterally in Text-Fig. 18.



Nymph of *Ichthybotus hudsoni*.

FIG. 32.—Feathered hair from leg, greatly enlarged.
FIG. 33.—Claw of third leg, greatly enlarged.
FIG. 34.—Legs, × 24.

The male may at once be distinguished from that of *I. hudsoni* McL. by its very dark coloration and its brown hindwings, as well as by the morphological differences given for the appendages."

The legs are illustrated in Text-Fig. 36.

"SUB-IMAGO, female.

Total length, 16.5 mm.; forewing, 19 mm.; hindwing, 7mm.; expanse, 40 mm. Generally resembling the same stage in *I. hudsoni*, but with the following differences: The whole body, legs and appendages are a dull earthy greyish-brown; the forewing has the ground colour pale greyish tinged with yellowish, the pale basal patch pale orange, the costal band dull purplish-brown, and the two oblique clouds a medium fuscous and more sharply angulated below R_1 than is the case in *I. hudsoni;* the hindwing is dull purplish-brown, paler towards the base and posterior margin. (In *I. hudsoni* the hindwing is pale greyish with two oblique clouds of medium fuscous). Ventral valve entire, not bilobed as in *I. hudsoni* (Text-Fig. 19b). Cerci, 8 mm.; appendix dorsali, 6.5 mm. long.

Locality—Matai River, Nelson; taken 29th December, 1920." (Tillyard).

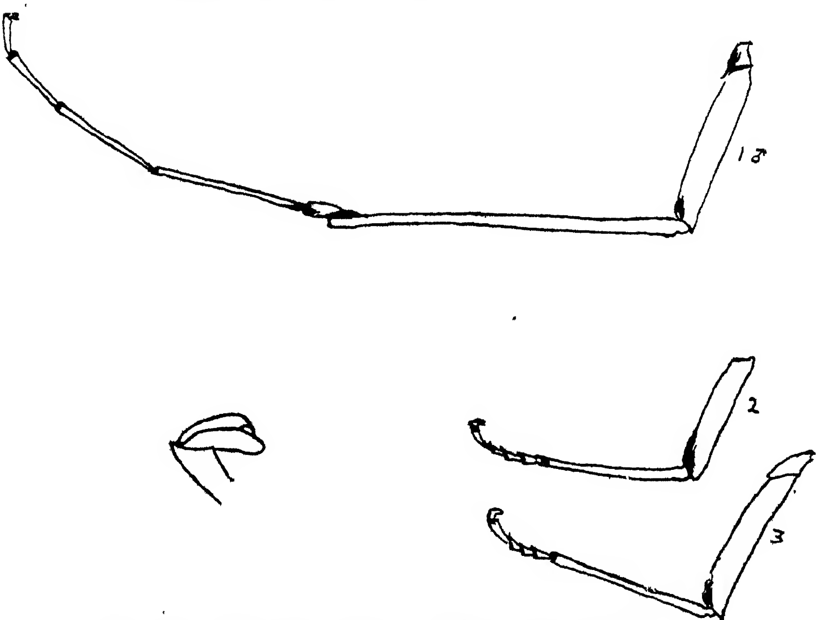


FIG. 35.—*Ichthybotus hudsoni.* Legs of male imago. × 8.

NYMPH.

Of this stage, Dr. Tillyard writes*. . . .

"This latter larva does not differ very much from the larva of the North Island species, *I. hudsoni*, but is smaller and darker in colour. The specimens which we found were in loose, coarse, mixed shingle and mud in the river bed, not actually tunnelling in clay, though the latter is the usual habit of the North Island species."

A single specimen, captured recently in the Gowan River, Nelson Province, was practically indistinguishable from *I. hudsoni*, save for a reddish tinge dorsally on the head, mandibular tusks and canines.

*In a recent letter.

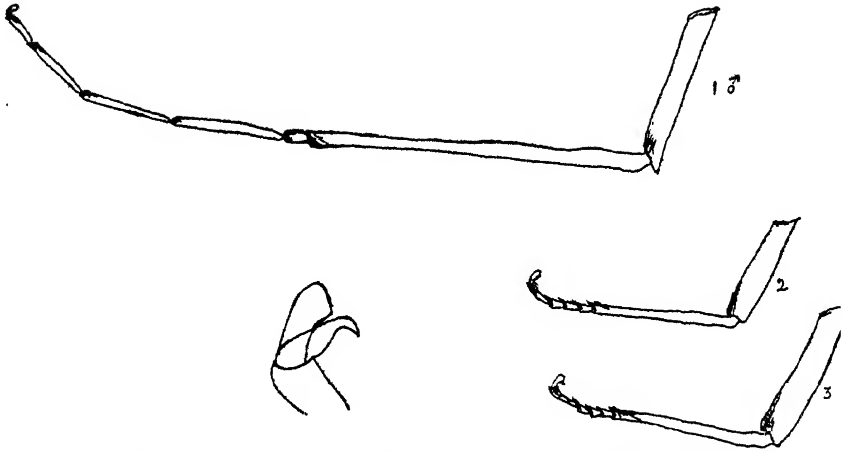


Fig. 36.—*Ichthybotus bicolor.* Legs of male imago. × 8.

Family Siphlonuridae.

The genera, which this family contains, are of especial interest, particularly as regards the nymphs as these possess many unique features, quite unlike those of any mayfly nymphs found outside Australasia.

Because of this, it is impossible to adopt, in their entirety, at all events for the nymphs, the characters for the Sub-family Baetinae given by Needham (8), or to adopt those of Lestage's sub-family Siphlonurinae, with both of which the family about to be described corresponds to a considerable degree.

Needham in his classification (8) states—"Sub-family Baetinae: a very heterogeneous series, only definable as lacking the characteristics of the other two" (i.e., sub-families Ephemerinae and Heptageninae) "and including five fairly distinct groups". . . .

(It should be pointed out that Needham's sub-families would correspond to present-day families, as his work was written before mayflies had been accorded ordinal rank).

In spite of the wide range which Needham's statement allows and the small number of sub-family characteristics—

> 'Mandibles without projecting tusk-like ramus
> Gills not as in Ephemerinae
> Eyes lateral: form of body various: claws smooth or toothed below,'

the fact that one of our genera (*Ameletopsis*) has the eyes placed dorsally would prevent our adopting this classification; moreover, the range of Baetinae is so wide that it would include the New Zealand members of the family Leptophlebiidae as well.

Lestage (10) is rather more detailed in his keys: for his family Baetidae he gives—

> 'Branchies externes, dorsales ou latéro-abdominales, mais toujours visibles.'

'Mandibles très courtes sans aucun prolongement antécéphalique: pattes grêles ou dilatées mais inaptes à fouir; branchies jamais plumeuses': 'Yeux latéraux; corps peu ou pas aplati dorso-ventralement, généralement cylindrique.'

and for the sub-family SIPHLONURINAE—

'Ongles jamais plus longs que les tibias, parfois bifides. . . . . parfois ongles simples et alors branchies simples, bi- ou mono-lamellaires, mais sans branchies auxiliares, et les pattes faiblement ciliées.'

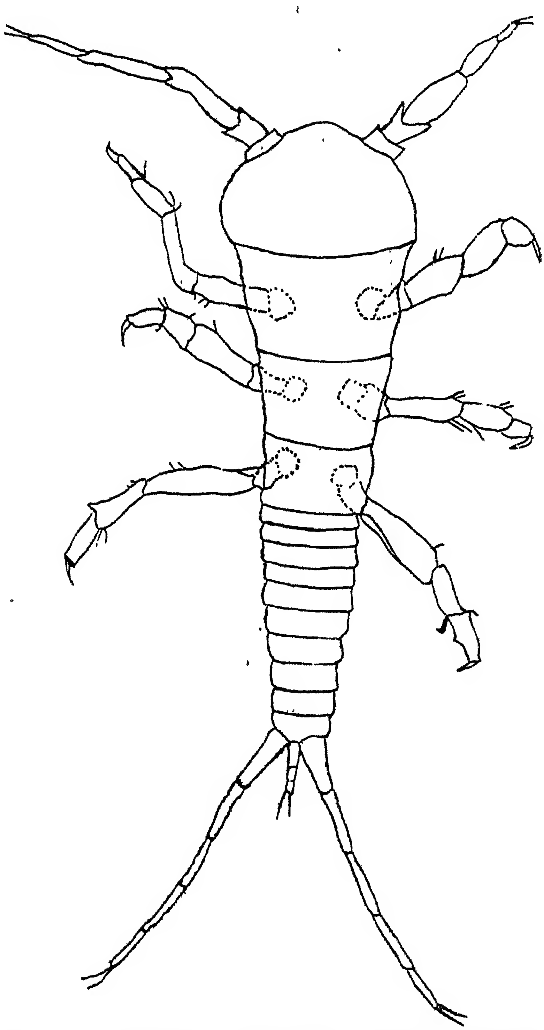
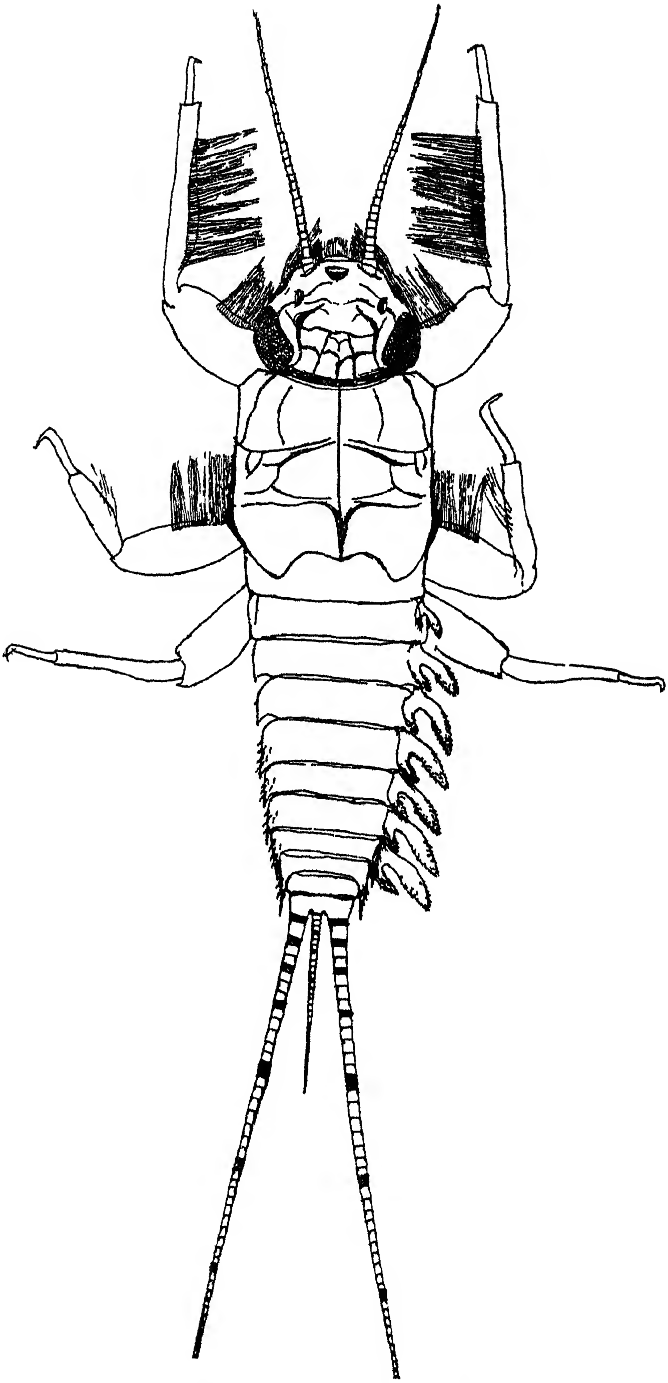


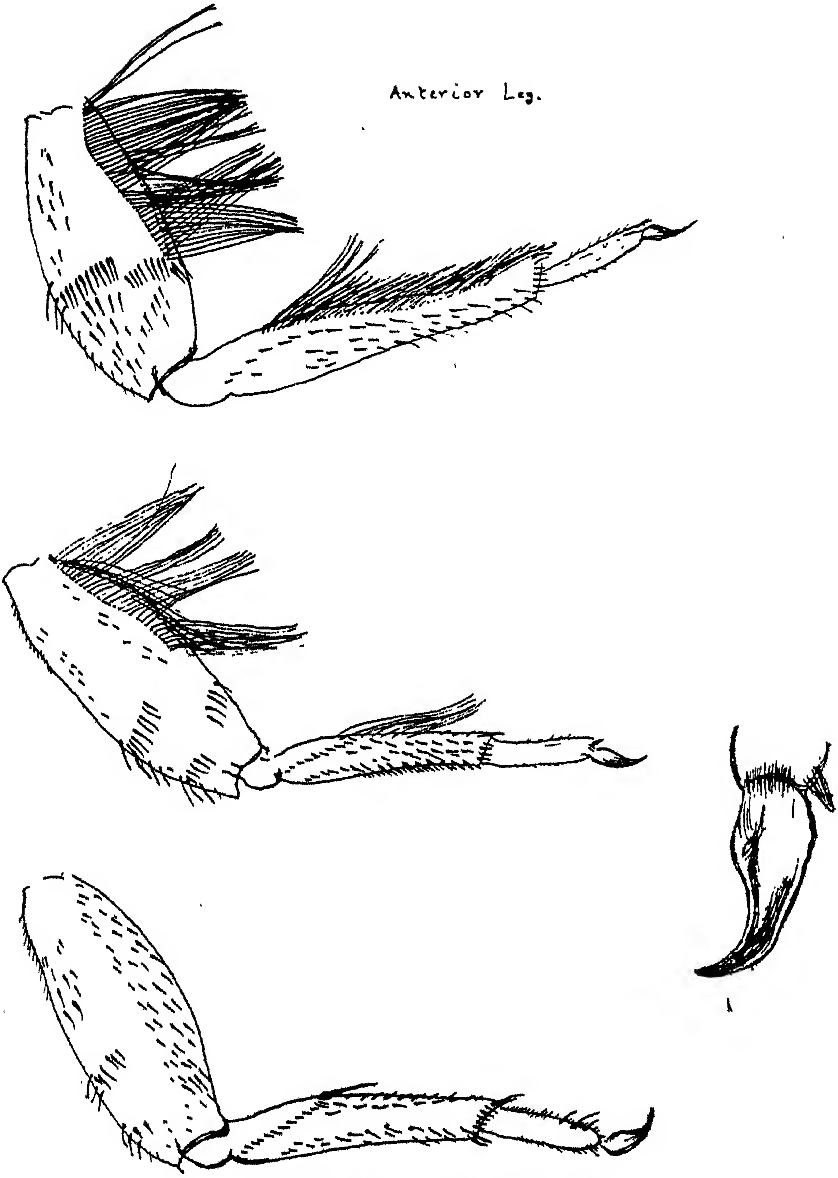
FIG. 37.—*Coloburisus humeralis,* 10 days' old larvule.

Here again *Ameletopsis* does not conform to a number of these conditions. The body is rather pronouncedly flattened dorso-ventrally, the eyes are dorsal, the lateral tails are haired on *both* sides.



Nymph of *Coloburiscus humeralis*

FIG 38.—Immature nymph. × 24. (Gills shown on right side only).



Nymph of *Coloburiscus humeralis.*

FIG. 39.—Legs, × 24; and tarsal claw, much enlarged.

And *Coloburiscus* could also not be included here, for its legs are not thin and the first two pairs carry long fringes of hair: moreover, the gills are not lamellate and the tails have very short hairs in whorls on both sides.

I therefore propose the following as the nymphal characters for the family SIPHLONURIDAE:

Description.—Nymph of the swimming type; body usually somewhat cylindrical. Eyes generally lateral. Mandibles short, not extending in front of head. With seven pairs of single gills, inserted dorsally or latero-abdominally. Legs short. Claws seldom toothed underneath. Caudal setae *either* strongly fringed with long hair throughout, all three sub-equal in length and shorter than the body, *or* with very short hair in whorls, in which case the lateral setae are about equal in length to the body and the median one is very short.

The adult differences are by no means so great and are all covered by Tillyard's characters for this family, as shown by the preceding key.

There are four genera: *Coloburiscus* Eaton, *Oniscigaster* McLachlan, *Ameletus* Eaton and *Ameletopsis* n. g.

Genus COLOBURISCUS Eaton (1887).

Adult.—"Forelegs of male about as long as the body (when dried, 1 1-10 as long); tarsus about as long as the tibia, and this about $1\frac{3}{5}$ as long as the femur; diminishing sequence of tarsal joints 2, 3, 4, 5, 1, the first joint nearly $\frac{3}{5}$ as long as the second. Foreleg of the typical female about 7/11 as long as the body; tarsus about $\frac{5}{6}$ as long as the tibia, which is about $1\frac{1}{2}$ as long as the femur; tarsal joints in lessening length rank 5, 2 subequal to 3, 4, 1, the first joint about $\frac{1}{2}$ as long as the second. Hind tarsus of the typical male about 5/12 as long as the tibia, and this about $1\frac{1}{3}$ as long as the femur; the first joint is about $\frac{2}{3}$ as long as the second, but both of them are short. Ungues in every tarsus each unlike the other. Hindwings well developed, oblong-oval, with the dilatation of the marginal area acute in front, and with relatively scanty neuration in the narrow axillar region. In the female abdomen the relative lengths of the 2nd-9th dorsal segments may be formulated approximately thus: 5, 8, 10, 12, 13, 13, $11\frac{1}{4}$, 8, 5; the first segment is thoracoid. The squarely truncate pleurae of segments 7 and 8 are minutely mucronate; those of segment 9 are produced posteriorly each into a short acute triangular point. Forceps-basis of male divided almost completely into two broad divisions; the limbs 3-jointed, the proximal joint subcylindrical, slightly enlarged or gibbous at the extreme base, and not much longer than the remaining joints combined. Ventral lobe of female bifid and acutely excised. Penis-lobe narrow, obliquely pointed; orifices of the seminal duct placed in proximity to the extreme points of the lobes; .... Median caudal seta rudimentary, only 1/10 to $\frac{1}{4}$ as long as the outer setae; these are about twice as long as the body in the male, and $1\frac{1}{2}$ as long as in the female. Oculi of male contiguous, or nearly so, above, obsoletely ascalaphoid, with the upper segments hemispherical and the lower relatively very small. Vertex of female head transverse; the occipital border raised in the middle above the level of the posterior orbits of the oculi. Median ocellus smaller than the others; not isolated, but situated upon the foremost prominence of the upper surface of the head. Pronotum of female broadly reflexed upon the mesopleurae, and in the middle deeply excavated behind." (Eaton).

NYMPH.

Head convex dorsally and with fringe of hair anteriorly. Eyes lateral. Maxillary and labial palps two-segmented and greatly en-

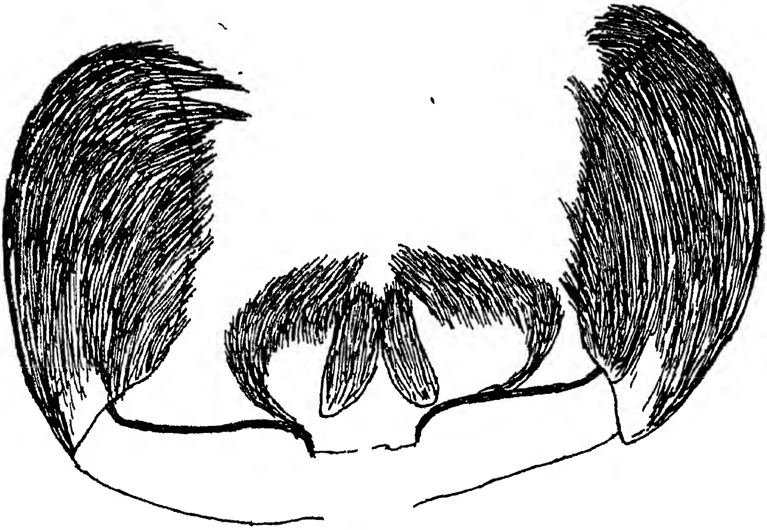


Fig. 43

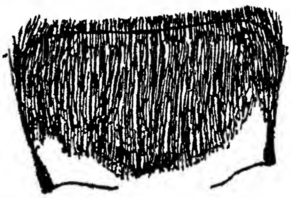


Fig. 41

Fig. 40

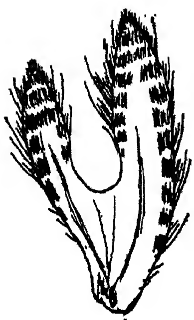


Fig. 42

Nymph of *Coloburiscus humeralis.*

FIG. 40.—Maxilla, Ca. × 50.
FIG. 41.—Labrum, Ca. × 50.
FIG. 42.—Gill. × 24.
FIG. 43.—Labium, Ca. × 50.

larged. Thorax very large and prominent. Anterior and middle pairs of legs with long fringe of hair anteriorly: order of length of legs 1, 3, 2. Claws not toothed. Latero-posterior angles of 3rd to 9th segments of abdomen project backward as sharp teeth. Caudal setae with very short hairs in whorls at joinings of segments. With a pair of gills on each of the first abdominal segments, held upright over the dorsum. Each gill composed of a divergent fork with a connective membrane basally and covered with spines.

Habitat in rapids and fast-flowing parts of streams.

There is only one species, *C. humeralis* (Walker), which is widely distributed throughout New Zealand.

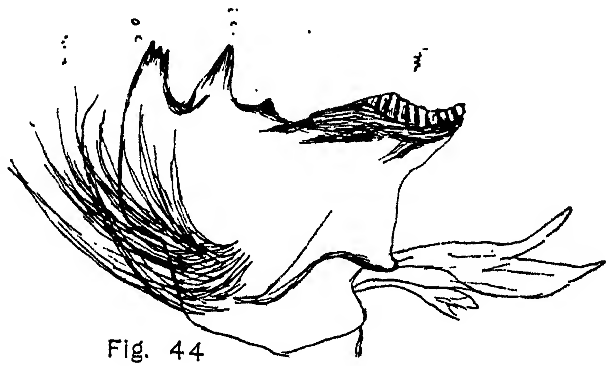


Fig. 44

Fig. 45

Nymph of *Coloburiscus humeralis*.
FIG. 44.—Mandible, ca. × 50.
FIG. 45.—Canines, greatly enlarged.

Coloburiscus humeralis (Walker).

IMAGO.

Length (excluding setae), 13.5 mm.

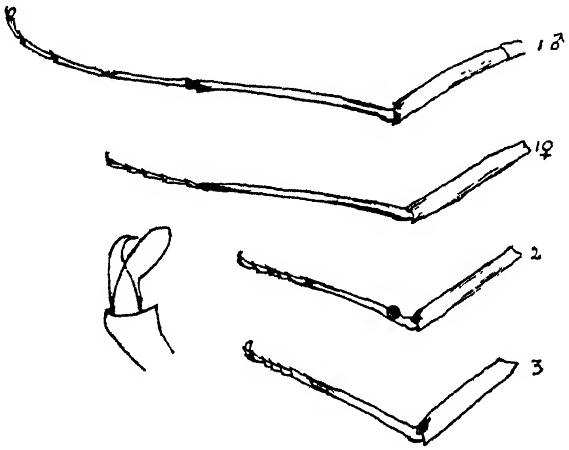
Head brown. Eyes of female olive, of male—upper part brown, lower part olive.

Thorax—notum burnt-umber: sternum reddish-brown, sometimes with pinkish areas round coxae.

Abdomen—burnt-umber with dark bands at posterior edges of segments: venter reddish-brown, last segment light fawn. Postero-lateral angles of segments seven, eight and nine strongly toothed backwards. Claspers (Text-Fig. 47) light fawn, becoming darker distally; three-segmented. Penes light fawn, short, well-separated. Caudal setae dull fawn, with black rings at joinings: median one very short, outer ones—male, 17 mm.; female, 15 mm.

Legs (Text-Fig. 46)—Anterior pair—Femora dark brown; tibiae dark fawn or pale yellow, banded dark brown at each end; tarsi dark fawn or pale yellow with distal end of each segment dark brown.

Other pairs—Pale yellow, touched with dark brown distally in all segments. Tarsi five-segmented; basal joint very short. Claws dissimilar, one sharp and hooked, the other broad and blunt.



Coloburiscus humeralis.

FIG. 46.—Legs of male imago and female foreleg. × 8.

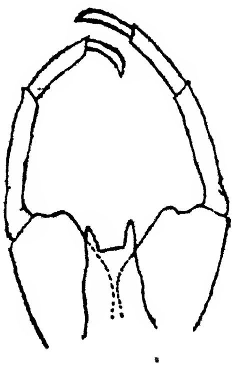


FIG. 47.—*Coloburiscus humeralis.* Genitalia of male imago. × 25.

Wings—Forewing vitreous: there is a yellow patch at the wing-base and the costal and sub-costal areas are pale yellow, deepening to bistre brown in the ptero-stigmatic region. In these anterior areas, the cross-veins are blurred and in the ptero-stigmatic region, they form a close reticulation. Hindwing vitreous, with yellow patch at wing-base. Humeral angle sharp.

Sub-Imago.

Wings (Pl. 54, Fig. 10)—Costal and sub-costal areas yellow, with vivid yellow patch at wing-base. The rest of the wing-surface is pearly. Veins dark grey, but lighter in the costal area. Cross-veins of costal area edged irregularly with grey, especially about half-way along.

The sub-imaginal stage lasts about two days.

The winged stages are in evidence from about the middle of October to the beginning of February.

Nymph.

Short descriptions of the winged stages of this insect have been written by Walker, Eaton (4) and (5) and Hutton (2). Hudson (1) includes the nymphal stage too, but a more detailed description is necessary.

This nymph (Text-Fig. 38) lives among the rapids and swiftly-flowing portions of the streams, though it occurs occasionally in more slowly-flowing parts. It is found attached to stones, rocks or boulders and among the vegetable debris, which is often lodged among the boulders in rapids. Here, it will cling with remarkable tenacity despite the force of the current, helped doubtless by the many spines with which its legs and the ventral surface of its abdomen are armed.

It is a poor swimmer, moving its legs in unison jerkily backwards and forwards, and there is at the same time a slight dorso-ventral movement at the tip of the abdomen: after a few spasmodic jerks, it often stops and curves the hinder part of its abdomen upwards and forwards.

The fringes of hair on its forelegs and mouthparts (Text-Figs. 38, 39) would seem to form a plankton straining apparatus, which enables it to secure food from the rapidly passing water without undue exertion, while its peculiar gills—unlike those of other mayfly nymphs—are held motionless, as it is unnecessary for the insect to move them to obtain fresh oxygen in the swift currents of its habitat. No other species of this order in New Zealand has succeeded so well in adapting itself to torrential aquatic conditions, and consequently it is the predominant nymph of the rapids.

Metamorphosis to the sub-imaginal stage occurs at the end of spring and throughout summer: before transforming, the insect seeks a stone or boulder above water level, on which the larval exuvia is left.

Description:

Length (excluding setae)—ca., 15 mm.

Head—Dark brown. Epicranium convexly arched and with a network of fine dark lines as shown in figure 1G.

Eyes—Very dark brown.

Antennae—About two and a half times as long as the head: filiform: segments of flagellum narrowing and lengthening from base to apex.

There is a row of minute spinules at each joint, pointing forwards and outwards.

Labrum (Text-Fig. 41)—1½ times as wide as it is long. Almost rectangular, but slightly broader anteriorly than posteriorly. Anterior and posterior margins straight and entire. Anterior-lateral corners rounded; posterior-lateral ones are strongly chitinised and form approximate right angles. Anterior margin and both surfaces strongly haired.

Maxilla (Text-Fig. 40)—Palp very much enlarged; 2-jointed; the apical one is the largest; it is falcate and very profusely haired. The galea-lacinia is considerably shorter than the palp; its outer edge is rounded, its inner one is straight: both are densely haired and from the anterior inner corner a prominent spine projects inwards.

Mandible (Text-Figs. 44, 45)—Outer canine (o.c.) with three teeth, and inner one (i.c.) with three teeth: the middle tooth of the inner canine is small, and often hidden by the teeth on each side of it.

Prostheca (p.) with blunt tip, chitinised, with inwardly-directed brush of long brown bristles at base.

Labium (Text-Fig. 43)—The palps are 2-jointed and very large. Lower joint a little broader basally than distally; upper joint much broader than the lower one, ovoid and profusely haired. Paraglossae with outer edges curved convexly, inner edges straight: profusely haired anteriorly.

Glossae much narrower than paraglossae and covered with long hair (they are somewhat displaced in the labium figured).

Thorax—Colour—Windsor and Newton's permanent brown. The lateral edges and a median tract are darker than the ground colour of the rest of the dorsum, which latter is patterned with a tracing of darker lines. The segments are broader than those of the abdomen. The meso-thorax, as usual, is the largest segment and is wider than it is long: the pro-thorax and meta-thorax are somewhat shorter, being about one-third as long as they are wide: the latter is fused with the first abdominal segment.

The whole thorax is convex dorsally.

Wingpads rather small. Same colour as thorax.

Abdomen—Narrowing somewhat posteriorly. Dark umber-brown, becoming tinged with red posteriorly in immature specimens. Covered with hair dorsally.* Posterior edges of segments minutely denticulated, the denticales being directed backwards.* Latero-posterior angles of the third to ninth segments project backwards as sharp teeth, which lengthen progressively towards the posterior.

The pleura of these segments bear spines, which project outwards **and** backwards.

Ventrally—Somewhat lighter in colour. The surface is covered with small hairs and spines, becoming more numerous and larger posteriorly, and in the fifth to ninth segments, the posterior edges bear a row of stout spines: the sternum of the ninth segment bears a couple of large backwardly projecting spines medianly and immediately exterior to these is a pair of smaller ones.

Caudal setae—Median one, 5 mm.; outer ones, 14 mm.

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*Not shown in figure.

Colour—burnt umber: there are a number of dark bars at irregular intervals, mostly in the basal half and, in some specimens, there are broader dark sections in the middle of the outer setae: the distal half becomes gradually somewhat lighter. In immature nymphs the proximal half has a reddish tinge.

There are whorls of short hairs and backward-projecting spines at the joints of segments: underneath these and terminating the segments distally are whorls of flat-lying larger spines.

Gills (Text-Fig. 42)—Tracheal gills are borne on each side of the first seven abdominal segments—a previous writer (1) states 'six pairs of gills,' but I have only found this to be the case where one pair was missing through obvious injury. They are inserted latero-posteriorly, and are held by the nymph upright over the dorsum.

The gills become larger posteriorly, the increase in size being noticeable in the outer fork of each gill only: the first pair is considerably smaller than the rest.

Each gill is pedunculate and consists of a divergent fork, united in the basal half by a thin lamella. They are armed with numerous short spines, which occur mainly round the edges and towards the distal part. These spines are jointed at the base and can be made to lie flat along the gill surface but spring up when pressure is removed.

The writer suggests that this stout yet elastic armament protects the gills from damage by current-borne debris.

On the surface of the lamella are a number of fine hairs, which are recurved apically; under the surface lies an extensive ramification of tracheoles: a tracheal branch runs through the middle of each of the forks.

Legs (Text-Fig. 39)—Dissimilar. Those of the anterior pair are the longest, the median ones are the shortest. The tarsus is the shortest joint in each leg. In the anterior pair, the femur is shorter, in the second pair longer than the tibia; in the posterior pair these segments are sub-equal.

Claws (Text-Fig. 39)—Alike in each leg, curved and hooked at tip: not toothed underneath.

Anterior pair—Femur greatly dilated; ovoid; there are two long fringes of hair on the proximal two-thirds of the ventral edge and a few small spines on the anterior surface of the proximal portion. The distal third of this surface is covered with large spines of which there are two half rows, in echelon, which start from the place where the ventral fringes of hair end; from here to the distal end, the surface is profusely spined.

Tibia with long fringe of hair on the ventral edge: the anterior surface is covered with short, thick spines and there is a row along the distal edge.

Tarsus has the anterior surface covered with short hairs and a fringe of them on the distal edge.

The function of the fringe of long hairs on the ventral edges of the femur and tibia is most probably that of a plankton strainer, for the nymph must find movement precarious in the swift water in which it lives, and consequently has to feed on whatever the water brings it.

Second pair—Femur not so dilated as in anterior pair; cuticular outgrowths similar, but the spines are not quite so numerous in the distal part.

Tibia covered with stout spines, some short, some long: no fringe of hairs, but a few straggly ones in places.

Tarsus as in anterior pair.

Third pair—Femur covered with stout spines: no fringe of hairs; ovoid, similar in contour to that of the second pair.

Tibia—No fringe: covered with thick spines; one, rather larger than the others, projects prominently from about the middle of the ventral edge forwards and outwards.

Tarsus as in anterior pair, and, in addition, there are a few stout spines on the ventral edge.

Genus ONISCIGASTER McLachlan.

In this genus are probably the most archaic types of mayfly now in existence. It has been studied by Eaton (4) and (5) and Vayssièrre (19) many years ago, though they had only dried or preserved specimens for examination. Eaton's description of the genus and of *O. wakefieldi* (4) has been included here.

Although three species have been described, it seems a little doubtful if *O. intermedius* is sufficiently distinct to be allotted specific rank.

The nymph appears to be indistinguishable from that of *O. distans*: both the imago and the sub-imago are also similar to those of *O. distans,* except for the lateral dilations of the 8th and 9th abdominal segments, which are sometimes very marked, sometimes less so. Moreover, in the Canterbury Museum there is a specimen of *O. wakefieldi* with the 6th segment laterally dilated in addition to the 7th, 8th and 9th as is usually the case, which would seem to indicate that these expansions are a variable feature.

The winged stages of *O. intermedius* are slightly larger than those of *O. distans,* though I have found one specimen of the latter, which was as large as *O. intermedius.*

With regard to *O. wakefieldi,* though I have never seen a living specimen, I am informed that it is still occasionally to be seen in the vicinity of Mount Grey, Canterbury.

The Canterbury Museum specimens of the imago show slight but constant differences from those of the imago of *O. distans,* viz., the latero-abdominal dilations, yellow caudal setae in place of brown ones and the proximal half of the forewing tinged with brown instead of the whole being hyaline.

Description:

"*Adult.*—foreleg of ♂ shorter than the body nearly in the proportion of 14 to 17; tarsus almost one and a third times as long as the tibia, and this nearly seven-eighths as long as the femur; gradation of the tarsal joints in the order of lessening length, 1, 2, 3, 4, 5, the first about one and a fifth times as long as the second joint. Foreleg of ♀ little less than half (9/20) as long as the body; tarsus about $1\frac{3}{4}$ as long as the tibia, and this $\frac{5}{8}$ as long as the femur; the rank of the tarsal joints in order of diminution is 1, 2 equal to 5, 3, 4, and the first is twice as long as the second joint. Hind

tarsus of ♀ about 1½ as long as the tibia, and this little more than ⅓ as long as the femur; the joints in order of shortening rank 1, 5, 2, 3, 4, and the first is twice as long as the second. Ungues each unlike the other in every tarsus. Hindwing well developed, obtusely subovate; dilatation of the marginal area obtuse in front; axillar region well developed, largely occupied by numerous long anastomosing veinlets from the inner margin. In the ♀ abdomen the relative lengths of segments 2-10 may be formulated thus:—6, 8, 8, 8, 8, 10, 11, 10, 6; the first is thoracoid. Pleurae of segments 2-5 in squarely truncate behind; those of segments 6-9 in ♀, or 5-9 in ♂, broadly and oniscoidally dilated, each narrowed and rounded off obtusely in front, and each produced behind into a short acute point separated by a small sinus from the hind border of the segment, so that this part of the abdomen is flanked by very conspicuous serratures; the pleural projections of segment 5 in the ♂ are narrower than the others. The 9th ventral segment is unprovided with a lobe in the ♀. Forceps-basis bipartite; the divisions, explanate, quadrangular, longer than broad, and remote from one another, might be reckoned as basal joints of the forceps-limbs. Forceps-limbs dactyloid, 4-jointed; the first joint short, tapering from the base; the second curved, longer than the others, and very slightly gibbous inside at the base. Penis small, perhaps retracted partially in dried examples. Median caudal setae of ♂ about ⅓, of ♀ one-sixth as long as the body; outer setae of ♂ about eight-ninths as long as the body. In the ♀ sub-imago the median seta is about one-third and the outer setae nearly three-quarters as long as the body. Oculi of ♂ remote above, oval and very prominent. Vertèx of ♀ head about as long as broad, slightly wider in front than behind; the occipital border raised suddenly above the level of the posterior orbits of the oculi. Median ocellus of ♀ much smaller than the others, isolated in a broad descending groove in front of and below the anterior edge of the upper surface of the head. Pronotum of ♀ rather broadly reflexed upon the mesopleurae; its posterior border (viewed from above) arched, with a very shallow median recess, which is not noticeable when viewed from in front.

"*Nymph.*—Abdominal tracheal branchiae recumbent upon the dorsum borne by segments* 1-6, diversiform and single, each inserted in a notch in the hind margin of the segment adjacent to the pleura; the foremost oblique, and somewhat resembling a truncate triangle with obtusely rounded angles, placed with the longest side inwards; the remaining five are formed each of a somewhat broadly obovate or oval pergamentose lamina with a large roundly expanded foliated lobe produced from its inner edge (defective in Fig. 18), the margins of which are irregularly erose and incised. The tracheation of the lamina gives it a curiously marbled appearance. Antennae shorter than the head, about 12-jointed in adolescence. Mandibular lobes strong and fang-like; the endopodite well developed; stipes well developed, circumscribēd distally by a shallow constriction. Palpus of maxilla I. a little longer than the lacinia; the third joint gradually tapering, pungent, about as long as the second and little shorter than the first, but not quite as stout as either of them; lacinia somewhat lanceolate, with very few hairs on the oblique crown close to the point, and with short ciliae mingled with a few slender curved spines on the inner edge preceded by a few very short hairs nearer the stipes. Laciniae of maxillae II. falcate, nearly of the same breadth as the narrowly ovate-lanceolate lobes of the labium; first joint of the palpus stout; second joint less stout and slightly curved, very little enlarged and almost squarely truncate distally, about as long as the first joint; third joint about half as long as the second, less stout, and somewhat elongate-oval. Median lobe of the tongue subquadrangular, with the distal corners rounded, longer than broad and slightly retuse, subequal in length to the paraglossae, of which the terminal margins with that of the median lobe constitute together an arcuate curve; paraglossae dilated distally very moderately. Hind leg a little longer than the fore leg; tarsus (claw excluded) nearly 1½ as long as the tibia. Abdomen carinate above longitudinally in the middle; the carination in segments 2-9 produced into short

*Eaton had not seen nymphs of *O. distans* and *O. intermedius*. In these, at all events, there is a pair of microscopic gills on the seventh abdominal segment.

points, each projecting a little over the base of the next segment; pleurae in segments 1-9 oniscoidally dilated, forming recurved acuminate serratures. Median seta plumose, the others ciliate inside, each in its distal three-fifths; outer setae about ½ as long as the body.

"Type—*O. wakefieldi* McLach.

"Distribution—New Zealand." (Eaton).

Oniscigaster wakefieldi McLach.

"*Sub-Imago* (dried).—Wings, in opaque view, light sepia-grey; neuration generally piceous, but the principal nervures become pale basewards; the cross veinlets situated in the portions of the forewing bounded posteriorly by the inner and terminal margins, and in front by the outer half of the sector (4) and the inner half of the pobrachial (7) nervures, and all of the cross veinlets in the hindwing are narrowly edged with faint nebulous dark bordering; those in the anterior portion of the forewing (with the exception of those in the extremity of the pterostigmatic space) are edged more or less broadly with piceous—most broadly so in the marginal, submarginal, and the next adjoining areas—and their bordering in the basal halves of the first two areas is confluent to a variable extent; between the great cross vein and the last-mentioned cross veinlets the membrane is pale, contrasting conspicuously with the adjacent parts; and in proximity to the wing-roots the base of the forewing from the radius (3) to the inner margin is somewhat pale, both membrane and nervures; and so again to a small extent is the membrane in proximity to the bifurcation of the praebrachial (6) nervure. Setae dull pale yellowish.

"*Imago* (dried)—♀.—Notum dark pitch-brown. Abdomen of a duller colour than the notum on the dorsum, but nearly as dark, probably discoloured considerably in drying; in segments 2-6 the trachae appear to be pale and the joinings of the segments dark; the sides of every segment in proximity to the pleurae are more or less dark; segments 6-9 are traversed lengthwise by a fine median black line, and are marked each by a pair of elongated dark spots or short streaks, one on each side of the line, at the base; the pleural expansions of these segments, and in 9 and 8 a forked longitudinal streak just above them on each side, are also dark. Venter light yellowish-brown, with black or piceous markings; the markings comprise in each of segments 2-7 a large blotch on each side, gradually rounded off towards the base of the segment, intersected by the pale descending trachae near its anterior termination, and leaving only the joining pale; also a transverse streak at the joining, tapering to a point from the middle in both directions, whence is produced a short pointed streak or triangular cusp pointing forwards in the middle of the hind border of the segment; also a pair of small dots or oval spots, one on each side of the middle of the segment and in proximity to the point of the cusp; also the ventral ganglion nearer the base of the segment in the median line; and, lastly, another pair of larger oval spots set obliquely, and rather wider apart than the smaller spots, one on each side of the middle near the base of the segment; in segment 8 the smaller pair of dots is extremely small, and in 9 they appear to be totally absent, the larger pair alone remaining. Setae whitish-yellow, sometimes discoloured at the base. Wings vitreous, faintly tinted with light brownish (excepting sometimes towards the tips of the forewings, perhaps in consequence of their having been seized between finger and thumb at the time of capture); neuration piceous; cross veinlets dark-edged, nearly in correspondence with their edging in the sub-imago. Legs in opaque view dull light brown-ochreous, all with the base of the femur, a broad band before its extremity, one at the base of the tibia, one embracing the tip of the tibia and the basal half of the first tarsal joint, and all with the extreme tips of the joints of the tarsus and with the ungues black; in transmitted light the ochre changes to dull amber.

"♂. Very similar to the ♀, but perhaps rather lighter in colour. Setae pale dull yellowish. Forceps pale yellowish-brown. Length of body, 16-21; wing, ♂ 16, ♀ 19-21; setae, ♂ im. 17 and 5, ♀ subim. 13 and 7 mm." (Eaton).

Oniscigaster intermedius Eaton.

(Plates 55-56, Figs. 11 and 12).

Length (excluding setae)—Male, 20 mm.; female, 24 mm.

Head—Dark brown. Eyes dark brown with a tinge of olive. Ocelli dark brown.

Thorax—Dark brown with a few lighter markings.

Abdomen—Dorsum shining dark brown, becoming lighter and tapering posteriorly; the median portion of the posterior edge of the ninth segment is light. On each of the first eight segments is a light pair of crescent-shaped marks, horns pointing inwards. The eighth and ninth segments are dilated laterally and are toothed backwards at the latero-posterior corners, the teeth being more prominent in the ninth segment than in the eighth. The lateral margins of the ninth segment are convex.

Venter somewhat lighter than the dorsum. A dark marking, in shape like the ' broad arrow ' mark of the British Government, placed antero-medianly and pointing forward, is found on each segment.

Claspers (Text-Fig. 55)—Dark brown, becoming much lighter distally. They appear to be five-jointed, but Eaton considers the basal portion to be part of the forceps-basis and defines them as four-jointed. Penes dark brown; small.

Caudal setae fawn with dark brown markings at joinings: outer ones—male, 22 mm.; female, 21 mm.: median one—male, 6 mm.; female, 7 mm.

Legs (Text-Fig. 54)—All segments light brown, tipped with dark brown at both ends. Claws dissimilar; one hooked and sharp, the other broad and blunt.

Wings—Vitreous, except for ptero-stigmatic region of forewing, which is light fawn: veins dark brown, in marginal and sub-marginal areas heavily bordered with dark brown, giving them a blurred appearance. There is a light brown blotch at the anterior of the wing-base in both wings, becoming dark brown in the marginal and sub-marginal portions, i.e., those proximal to the humerus. Wing expanse—♀, 39.5 mm.; ♂, 35 mm.

Habitat—Wellington and Hawkes Bay provincial districts, North Island of New Zealand. Tableland of Mount Arthur, South Island.

The adult may be found from November to January.

Sub-Imago.

Wings (Plate 57, Fig. 13)—Blackish-grey; black neuration, thickly and darkly-edged in marginal and sub-marginal areas of fore-wing and anterior half of hindwing and faintly-edged with grey in posterior half of hindwing and the rest of the anterior half of fore-wing. In the forewing is a light space, just distal to the humerus and a light transverse band from the middle of the costa across to the tornus.

Duration of sub-imaginal stage is three days.

Nymph.

The nymph (Pl. 57, Fig. 14) is rather uncommon: it is extra-ordinarily local in distribution, but where it does occur, a number of specimens may be obtained readily.

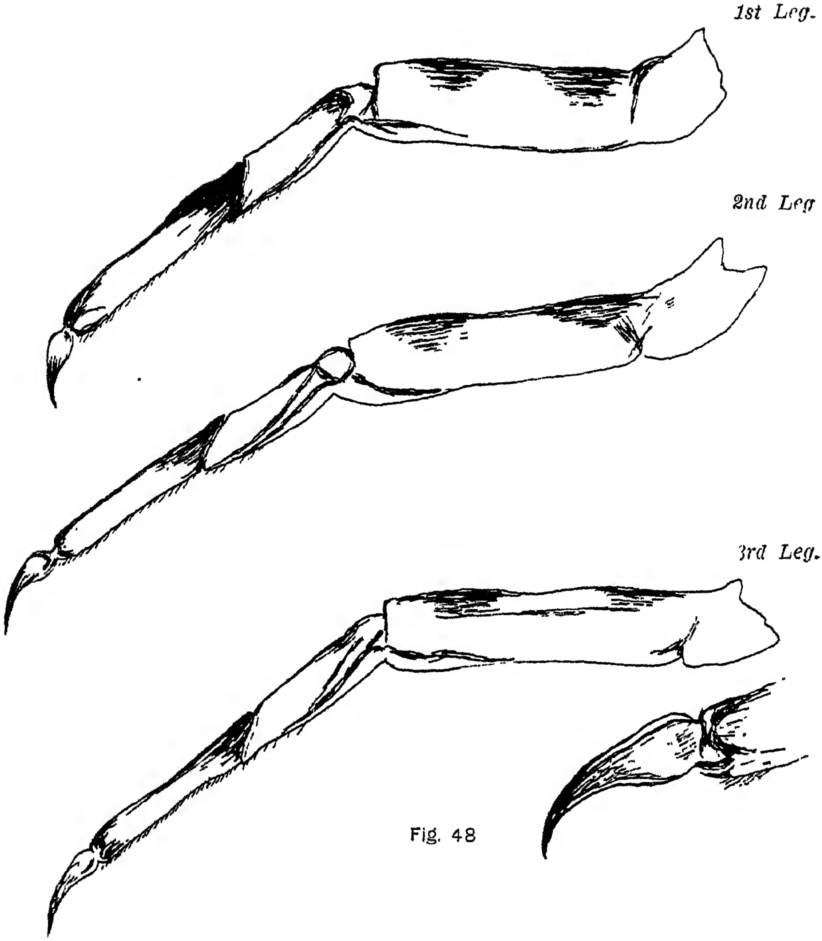


Fig. 48

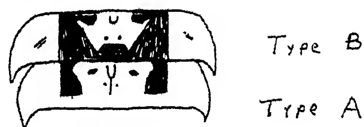


Fig. 49

Nymph of *Oniscigaster intermedius.*

FIG. 48.—Legs, × 20; and claw, × 45.

FIG. 49.—Diagram of types of ventral abdominal segments.

Its sluggish habits and marvellous camouflage make it very difficult to find: furthermore, it often buries itself in the gravel. Young specimens may be found in very fine gravel, but more mature nymphs occur on coarse gravel and boulders. It prefers pools and slow currents, but not stagnant water.

A curious trait is its preference for particular spots; thus, I have taken over twenty specimens from one small pool, whereas a protracted hunt over a hundred yards of adjacent stream-bed, containing many apparently precisely similar pools, has yielded a bare half-dozen.

The colour variation of this nymph is remarkable: it is sometimes brown, sometimes greyish-green, sometimes whitish, sometimes reddish, but the legs and venter show two clearly-defined types, referred to below as type A and type B.

Head—Small: held almost at right angles to the body: greyish-green, mottled with light brown.

Antennae—Short; twelve-jointed.

Eyes—Placed laterally; large; olive green.

Labrum (Text-Fig. 50a)—Nearly twice as broad as it is long. Anterior edge nearly straight—only slightly curved medianly; profusely covered with inwardly-pointing spines, their tips curved inwards; this fringe extends along the lateral edges three-quarters of the way towards their posterior angles. These angles are somewhat oblique and very dark in colour. There are additional incurved spines on the anterior region of the dorsal and ventral surfaces.

Mandible (Text-Fig. 50)—Both outer (o.c.) and inner (i.c.) canines have four teeth, but so placed that the examination of a slided specimen seldom reveals more than three. Prostheca (p) narrow and shorter than the canines, with rounded, non-chitinised tip and covered with fine, short hair. Placed interiorly and curving inwards is a brush of long light brown hair. Molar surface (m) with about 10—the number varies—parallel ridges with serrated edges.

Maxilla (Text-Fig. 51)—Palp three-jointed; somewhat longer than the galea-lacinia: the basal joint is the broadest, the distal one the narrowest: they are all about the same length, the middle joint being very slightly shorter than the two others. There are a few spines on the edge of each joint and a number situated apically on the distal one. The galea-lacinia narrows anteriorly to a point; from the places where it begins to narrow to the apex, it is fringed with hair.

Hypopharynx (Text-Fig. 52a)—Median piece projecting slightly beyond the superlinguae anteriorly, lateral angles rounded, lateral margins somewhat gibbous. The surface appears corrugated but unhaired. Superlinguae, each about half as wide as the median piece, becoming narrower basally. The anterior and interior margins are heavily fringed with hair.

Labium (Text-Fig. 52)—Palp three-segmented: basal segment broadest and longest, very dingy and covered with short incurved spines: second segment with a few spines: distal segment much shorter and somewhat narrower than the others, its apex pointed and covered with spines. Paraglossae falcate with numerous spines anteriorly. Glossae a little but not very much smaller than the para-

glossae, their inner edges somewhat concave, touching each other distally; their outer edges are slightly convex, the curvature increasing anteriorly; the inner anterior angles are quadrangular with the extreme corners, only, rounded. The glossae bear a number of marginal spines.

Thorax—Greyish-green, mottled with light brown. Pronotum narrow: mesonotum very broad, V-shaped, almost covering metano-

Fig. 50

Fig. 51.

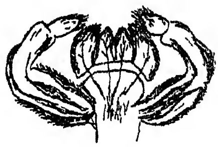
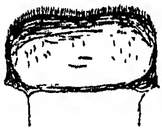


Fig. 52



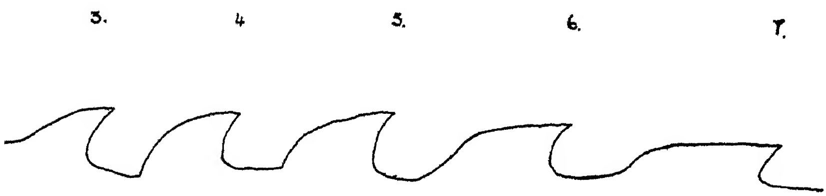


Fig. 53

Nymph of *Oniscigaster intermedius.*

FIG. 50.—Left mandible and labrum. × 30.
FIG. 51.—Right maxilla. × 30.
FIG. 52.—Labium and hypopharynx. × 30.
FIG. 53.—Dorsal crest (2nd to 7th segments). × 20.

tum. Wingpads small, greyish-green, covering the first two abdominal segments only.

Legs (Text-Fig. 48)—Short; robust. Order of length, 3, 2, 1: this is accounted for by the differing length of femur, the tarsi and tibiae not varying in length. The tarsus is longer than the tibia. The claw is about half the length of the tarsus, swollen at the base, and pointed and hooked apically: it is untoothed. There is a row of spines on the ventral edges of the tarsus and tibia.

Eaton in his plate 51, vol. 3, *A Revisional Monograph of Recent Ephemeridae, Trans. Linn. Soc., Lond.,* describing the nymph of *Oniscigaster wakefieldi,* shows a row of spines on the dorsal edge of the leg. Either this is an error, or it offers a means of distinguishing the two species in their nymphal stages, and apart from this difference, his description appears to tally, so far as it goes, with the species described in this paper.

Colouration—Type A—Femora greenish-white, with brown bar two-thirds of the way towards the distal end. Tibiae white, with tinge of green. Tarsi white, with dark greenish-grey mark at proximal end and dark brownish-grey mark distally.

Type B—Femora yellowish-white, with brown bar two-thirds of the way towards distal end. Tibiae light yellow, with brown mark at each end. Tarsi light brown, darker at each end. In both types the claws are stout, brown and strongly curved.

Abdomen—Type A—Greyish-green with brown markings. Type B—Light brown, mottled with light yellow. The first nine segments have whitish pleurae laterally flanged, the posterior lateral angles of which curve backwards and terminate in sharp, black points. The tenth segment has no flanges, but the posterior edge, which is dark-rimmed, slopes back medianly, terminating in a rounded point; there is a pair of medianly placed brown dots on this segment. The first nine segments are keeled longitudinally along the median line, and produced into sharp points, projecting over the next (posterior) segment (Text-Fig. 53).

Venter (Text-Fig. 49) Type A—Ground colour dingy white with maroon markings, placed laterally on each of the 2nd to 9th segments and a thin band joining them running along the anterior edge. There are also two median markings of this colour, one quarter of the way from the anterior edge, and two smaller dots closer to the median line and half way towards the posterior edge. The flanges are dingy white and the markings on each segment somewhat resemble a horned owl.

Type B—Ground colour light chocolate, lateral flanges flavescent: the second to seventh segments have a prominent whitish W mark medianly (eighth and ninth segments faintly so), with two paired brown markings inside the apices of the arms of the W and two small brown dots within the lower part. Faint indefinitely-shaped brown areas jut out into the flanges.

In both types the tenth segment is very dingy and emarginate posteriorly.

Caudal setae—Short; white, except for a small area towards the tip, which is black. Median one with a long fringe of hair on both sides, outer ones fringed on inside only: there are circles of minute

black spinules at the posterior edges of each segment. The outer setae are slightly longer, curving inwards somewhat towards the tip. There is a narrow proximal area, which is also black. Length, 6 mm.

Gills—On the first six abdominal segments. They are single, lamellate but diversiform. Their general shape is roundish, their colour olive green* beautifully marbled with white. The first four are about the same size, the fifth is smaller, and the sixth very small. They are held lying inwards over the dorsum and almost meet along the median line. They appear to correspond exactly with those of *O. wakefieldi*, wonderfully well illustrated in Eaton's plate, mentioned above.

Attached to the posterior edge of the seventh abdominal segment is a minute pair of gills, which have been overlooked by previous writers. The discovery of this microscopic pair was made by Professor Percival of Canterbury College, Christchurch, New Zealand, who drew my attention to them in a letter dated 1/10/29.

Oniscigaster distans Eaton.

This species appears to be indistinguishable from *O. intermedius* in the nymphal stage, but the winged stages are without lateral abdominal flanges on any of the segments.

This species is far commoner than the preceding ones and can be found in many of the well-bushed and more inaccessible streams of both Islands. I have not found specimens in streams, the banks of which have been denuded of vegetation, and it is probable that in such places it has been exterminated by birds.

Genus AMELETUS (New Zealand Type).

In all stages of the New Zealand species of *Ameletus*, a number of small differences from the generic type may be found, and it will probably be necessary to found a new genus for them. Dr. Tillyard is investigating some related species in Australia and, as he is also conversant with the New Zealand species, he will probably redefine the genera of the SIPHLONURIDAE for the whole Australasian region. Until then, the following may be taken provisionally as generic characters—

ADULT.

Foreleg of male sub-equal to length of body, of female ½ to ⅓ as long as the body: femora with heavy dark median bar: hind tarsi slightly shorter than the tibiae: †claws alike narrow and hooked in each tarsus. Median caudal seta very short, outer caudal setae about as long as the body. Genital forceps four-segmented, basal segment very short, second segment longer than all the others combined: penes well separated, narrow, acuminate. Forewing with tornus about $^2/_5$ the length of wing from wing-base: cross-veins in pterostigmatic area simple, not reticulated. Hindwing with humeral angle a gently-curved obtuse angle.

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*In some specimens the gill surface is red.

†Eaton (4) at first included *A. ornatus* in the genus *Chirotonetes*, which has the claws alike, but later (5) transferred the species to the genus *Ameletus*, stating the claws were dissimilar.

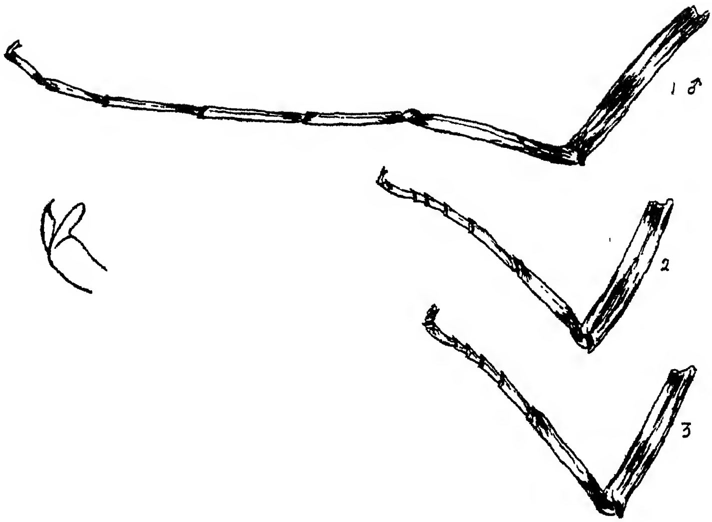


Fig. 54.—*Oniscigaster intermedius.* Legs of male imago. × 8.

Nymph.

Nymph torpedo-shaped. Head small. Antennae short. Eyes lateral. Labial and maxillary palps three-jointed. The canines coalesced. Wingpads large and conspicuous. Legs short, robust, subequal. Claws minutely toothed underneath. Abdomen tapering posteriorly. Postero-lateral angles of segments sharply-toothed backwards. Caudal setae about half as long as body; the median seta is slightly shorter than the others and is plumose; the outer setae are

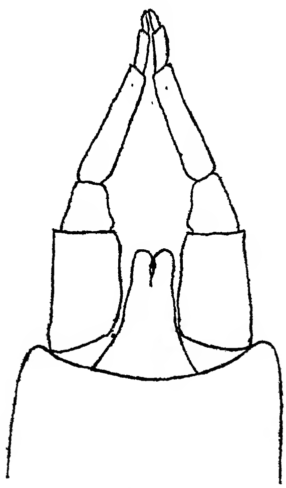
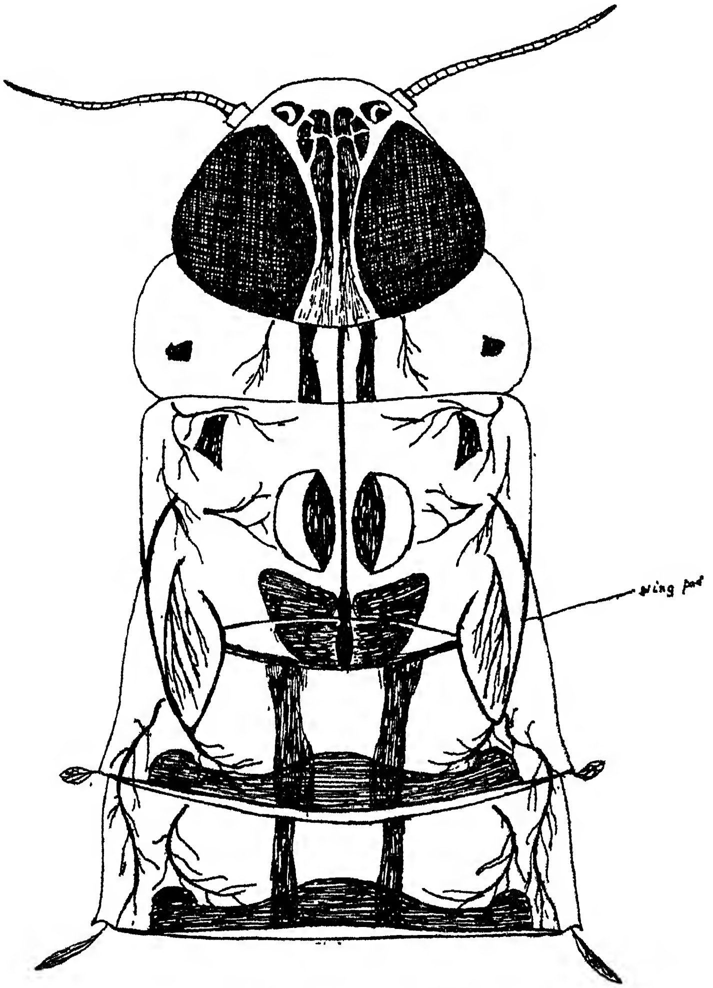


Fig. 55.—*Oniscigaster intermedius.* Genitalia of male imago. × 25.

thickly-fringed with hair on the inner margins only. Simple lamellate gills are borne on the first seven abdominal segments: they are held laterally. The edges of the lamellae are finely-toothed and the venation is pinnate.

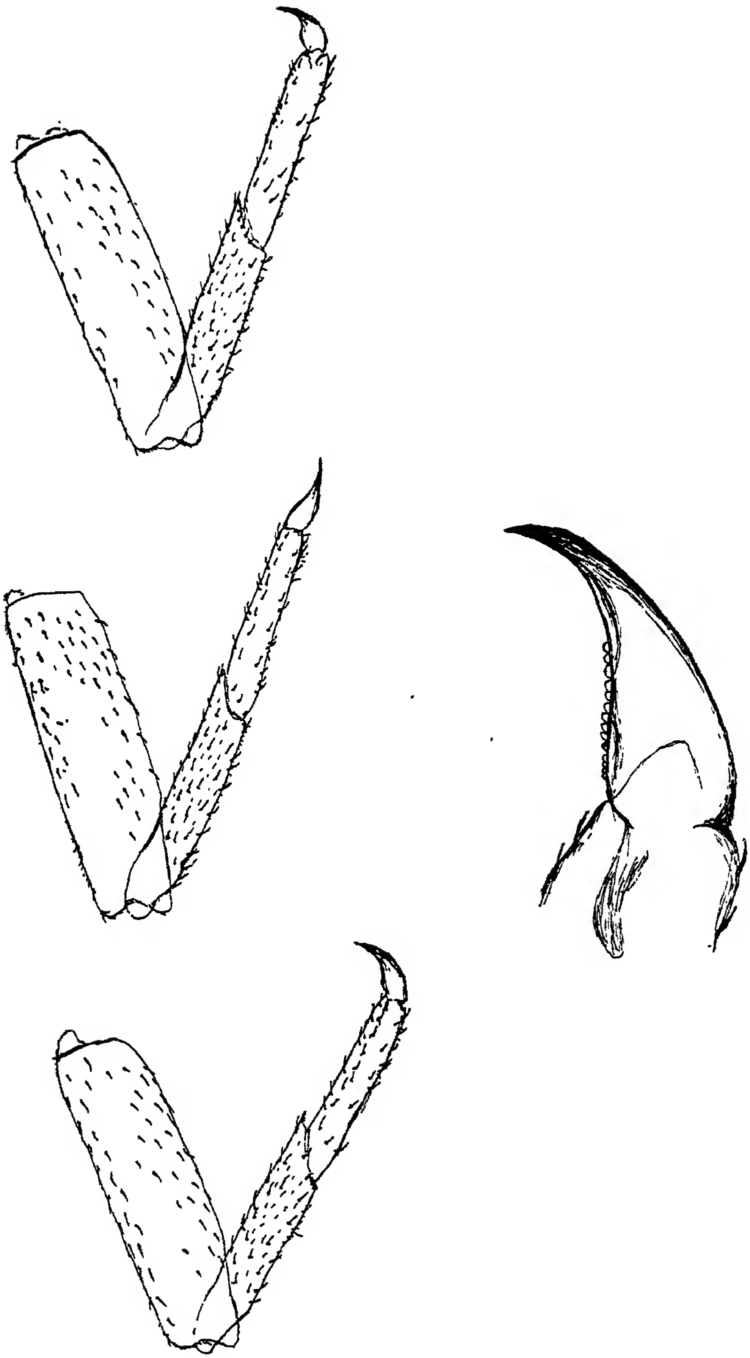
It will be noticed that the mouthparts in the species described are quite different from those of *Ameletus* species in the Northern Hemisphere and when the adult characters of local *Ameletus* species have been thoroughly re-examined, it is quite likely that a new genus will have to be established for them.

There are two species—*A. ornatus* (Eaton), described below, and *A. flavitinctus* Tillyard.



Nymph of *Ameletus ornatus.*

FIG. 56.—Thorax and first two abdominal segments. × 25. (Immature nymph; wingpads undeveloped.)



Nymph of *Ameletus ornatus.*
FIG. 57.—Legs, × 25: tarsal claw, greatly enlarged.

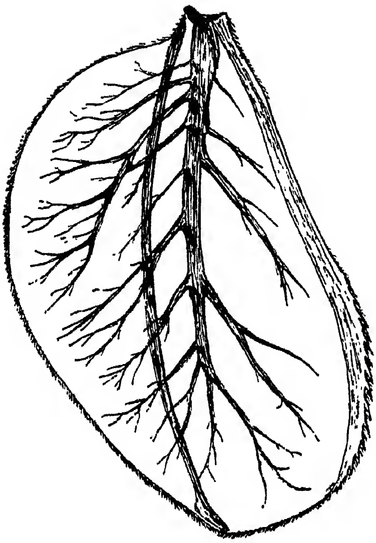
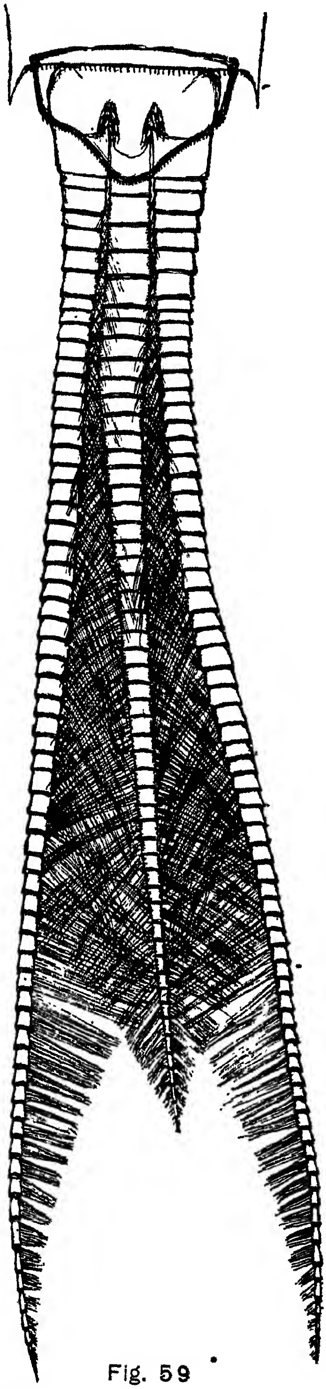


Fig. 58



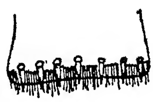


Fig. 59

Nymph of *Ameletus ornatus.*

FIG. 58.—Gill. $\times$ 25.

FIG. 59.—Caudal setae, $\times$ 25, and segment of one, much enlarged.

A female sub-imago of this latter species was taken at Waihi, near Lake Taupo, on November 26th, 1919, by Dr. Tillyard, who named it and described it and its later (imaginal) stage (6).

It was not till November 23rd, 1929, that I found several strange looking *Ameletus* nymphs in the River Wainui-o-mata and its tributary George's Creek, near Wellington. On November 26th, exactly ten years after Dr. Tillyard's discovery, one of the nymphs changed to a female sub-imago, and I was able to recognise it from Dr. Tillyard's paper and thus identify the nymph.

Ameletus ornatus (Eaton).

Imago.

Length (excluding setae)—14 to 15 mm.

Head—Dull brown. Eyes of female, olive; of male, olive in upper part, fawn in lower part. Ocelli black.

Thorax of male, pitch brown dorsally; of female, brown.

Abdomen—First segment almost hidden by metathorax. Ground colour dark fawn, becoming somewhat lighter distally, except in the ninth segment, which has a greenish tinge: third to ninth segments have paired brown longitudinal markings medianly: posterior edges of fourth, fifth and sixth segments are dark-rimmed. Venter, light ochreous with greenish tinge. Claspers (Text-Fig. 66), light fawn, four-segmented. Penes, light brown, becoming darker distally. Caudal setae, light fawn, banded with dark brown, becoming lighter distally: outer ones, 16 mm.; median one, 1 mm.

Legs (Text Fig. 65)—Forelegs brown ochreous: femora banded with dark brown medianly and apically: tibiae and tarsi fawn, with dark markings apically. Other pairs flavescent with black or dark grey markings, viz., a band in the middle and another at the tip of the femora, a band at the tip of the tibiae, at the joinings of the tarsi and to some extent on the last three segments of the tarsi. Tarsi five-segmented.

Wings (Pl. 58, Fig. 16)—Expanse—male, 28 mm.; female, 34 mm. Surface of both wings yellow with some areas hyaline. In the forewing, the cross-veins are simple, and rather thick in the costal and sub-costal areas. Neuration black or dark brown. In the pterostigmatic area, the cross-veins are more closely set and there is a slight brownish tinge. Bullae on Sc., R1 and R2a.

Wings of Sub-Imago—Wings clouded with whitish-grey, mottled with black in the male, green in the female: wing-base yellowish. Veins brown. Cross-veins bordered with brownish-grey, their borders confluent in places, forming irregular-shaped areas.

Duration of sub-imaginal stage, two days.

Winged stages are in evidence from November to February.

Nymph.

This is the best example of the 'swimmer' type of mayfly nymph in New Zealand, its powers in this respect far exceeding those of any other Ephemerid in the country.

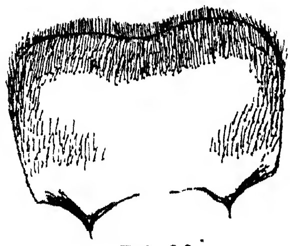


Fig. 60

Fig. 61

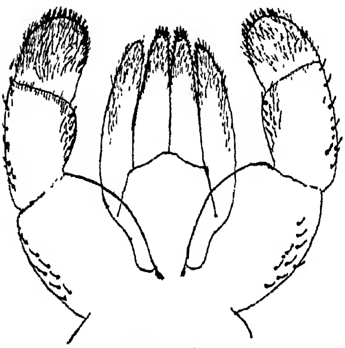


Fig. 62

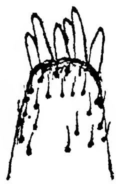


Fig. 64

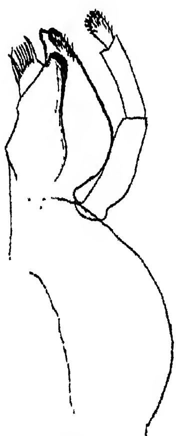


Fig. 63

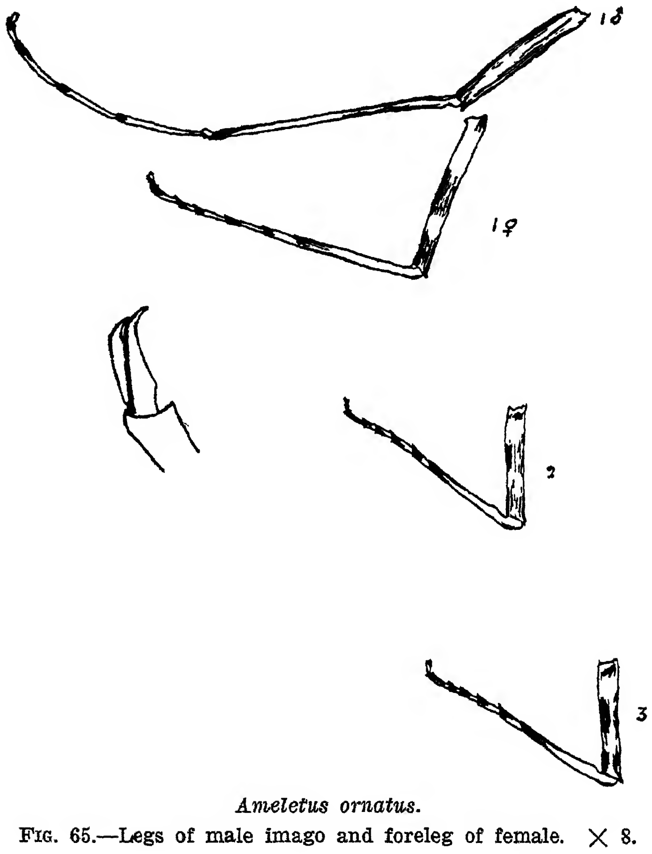
Nymph of *Ameletus ornatus.*

FIG. 60.—Labrum. × 40.
FIG. 61.—Mandible. × 40.
FIG. 62.—Labium. × 40.
FIG. 63.—Maxilla. × 40.
FIG. 64.—Tip of glossa, greatly enlarged.

Its distribution is widespread, as it occurs in most streams except the very sluggish ones.

The nymph of *A. ornatus* (Pl. 58, Fig. 15) can exist either in swift currents or in the pools between rapids: it is found both on the upper and lower surfaces of boulders, as well as on their vertical edges: it is also found on vegetation at the edges of streams.

When at rest, it has, more than any other mayfly nymph, the curious habit of swaying its setae and the hinder part of its abdomen gently, at intervals, in a dorso-ventral arc.



Ameletus ornatus.

FIG. 65.—Legs of male imago and foreleg of female. × 8.

Its movement is so rapid that to the eye it appears as a swift wriggling dart, of which the component motions cannot be perceived. Careful and prolonged observation, however, shows that the movement is made by rapid dorso-ventral shakes of the ' tail ' and of the posterior part of the abdomen, through a short arc. The legs appear to be used to assist movement and are not held folded back against the body, as in the case of the American *A. velox* Dodds (Dodds and Hisaw (14)).

Nymphs in captivity will often turn over on their backs if disturbed, and appear as if dead: whether this is a simulation of death

or an actual disturbance of balance, due to unknown conditions, is a matter of question: after an interval—which may vary from a few seconds to some minutes—they recover. When narcotised with chloral hydrate, they assume a similar posture.

The nymph becomes full-grown during the summer months, when it leaves the water and changes into the sub-imaginal stage on a stone or boulder.

It will be noted that there are considerable differences in structure, notably in the mouth parts, between *A. ornatus* and the species of Ameletus found in Europe and America; and, if further study reveals pronounced differences in the winged stages, it will be necessary to establish a new genus as Tillyard (6) suggests in his description of *A. flavitinctus* Tillyard.

The colouring of this nymph varies considerably in different localities.

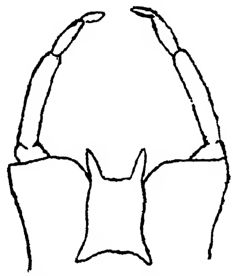


FIG. 66.—*Ameletus ornatus*: Genitalia of male imago. × 25.

Description:

Length (including setae)—Ca., 2 c.m.

Head—Small; greyish-green: axis at right angles to that of body. All the margins appear convex, viewed from above, and the head narrows somewhat anteriorly. The greater part of the dorsal surface is occupied by the compound eyes.

Eyes—Dark fawn or dark greyish-green: large: set close together.

Ocelli—Black.

Antennae—Short: subulate: sixteen-jointed: scape and pedicel colourless; flagellum flavescent at base and becoming greyish-green distally.

MOUTHPARTS:

Labrum (Text-Fig. 60)—About twice as wide as it is long. The anterior edge is densely haired and has a gentle inward bend medianly; the latero-anterior edges are rounded and from the sides extend backwards and very slightly inwards to the latero-posterior corners, which are obtuse-angled. The posterior edge has two backwardly-directed salients, one near each end, where the adductor muscles are attached. Numerous spines occur on the surface and round the edges, placed as shown in the accompanying figure.

Mandibles (Text-Fig. 61)—The canines (c) have coalesced and form a wide flattened projection with a ragged distal edge. The outer edge of this projection is strongly chitinised. The prostheca (p) is

a thin, pale, non-chitinised, finger-like process, interior to the canines, and accompanying this is an inwardly-directed brush of light brown hair; this is considerably larger than the prostheca.

The molar surface (m) bears ten parallel serrated ridges. The irregular, inner posterior, projecting tissue is part of the adductor muscles (ad. mu.).

Maxilla (Text-Fig. 63)—Palp three-jointed. Basal joint broadest and longest: middle joint somewhat shorter and narrower: the third joint is very much shorter than the other two; on it are several spines and in the distal part a number of small finger-like sensillae, shorter and broader than the spines.

The galea-lacinia is irregularly-shaped and has a fringe of hairs anterior-interiorly; there is a row of bristles rooted near the anterior-exterior edge.

Labium (Text-Fig. 62)—Palps three-jointed: very stout. The joints decrease in length and width from the base upwards. The two lower segments of each palp bear a number of spines: most of these are slightly curved, but a few are somewhat shorter, considerably thicker and straight. The distal joints are more densely spined, and placed apically are a number of the curious sensillae, mentioned above when describing the maxillary palp. The apices are slightly chitinised.

Paraglossae narrow, elongated, curving slightly inwards anteriorly and densely haired distally.

Glossae (Text-Fig. 64) a little longer than in the paraglossae. They are shaped like elongated cones with the tips truncated. Their interior edges touch posteriorly. The anterior parts bear spines and towards the tips, which are chitinised, are several of the afore-mentioned sensillae.

Thorax (Text-Fig. 56)—Ovoid in section.

Prothorax—Very short, being about one-third as long as it is wide at the sides and only about one-fifth as long as it is wide in the middle. The anterior edge is concave, the posterior one straight and the lateral ones slightly convex. The ground colour is greenish-white: there is a dark green line medianly with a brown ochreous band on each side of it: exterior to these bands are thin green linear markings: in addition, there is a brown ochre dot near each of the latero-posterior corners.

Mesothorax—Straight-margined anteriorly and posteriorly: it is nearly as long as it is wide: the lateral edges are slightly convex. The ground colour is greenish-white: the surface is elaborately marked with fine dark green lines: there are two pairs of brown ochre splodges, the first placed anteriorly and half way between the median line and the lateral edges, the second pair—somewhat larger—at the posterior edge, one mark on each side of the median line. The median line is dark green, and on each side of it, just anterior to the brown markings, are conspicuous oval ones, golden laterally, brown medianly, their major axes running anteriorly-posteriorly.

The *metathorax* is almost completely hidden by the meso-thorax, except for a narrow strip of the convex posterior edge, which is brown ochre, with a dark green median line.

Wingpads—Large: dark slate grey in colour: they cover the dorsum about as far back as the posterior edge of the second abdominal segment.

Abdomen—Tapers posteriorly: posterior-lateral angles of second to ninth sterna project backwards as sharp teeth.

Dorsum (Text-Fig. 56)—Ground colour faintly greenish-white in first eight segments. There are paired brown ochre longitudinal bands placed medianly and a similarly coloured band along the posterior edge of each segment. The extreme rim, which is darker, bears minute backwardly directed spines. All these markings become less pronounced posteriorly. Appearing in dorsal view as contiguous to each of these posteriorly-placed bands, but in reality beneath and partly overlapped by them, lies a narrow olivaceous softer portion in the anterior part of the next segment. The ends of the posterior bands terminate near the lateral edges as golden brown blobs. Exterior to these are the latero-posterior angles of the terga, which are blackened, and from below these, in the first seven segments, the gills project. The ground colour of the ninth and tenth segments is greyish-green, becoming darker posteriorly in each segment: as usual, the posterior edge of the tenth segment is not straight, but is in the form of a truncated triangle.

Venter—White.

Caudal setae (Text-Fig. 59)—Outer ones, 7 mm.; median one, 6 mm. The median seta is fringed with hair on both sides, the outer ones are fringed internally only.

(A previous writer (1) describes and figures the outer setae as fringed with hair on both sides, but I have never met with a specimen of this description).

The hair fringed are black in the proximal, white in the distal portion: the hairs become shorter distally.

There is a row of minute backwardly-pointing spinules near the posterior edge of each segment and just behind, closely adpressed to the surface, a compactly-set row of small, spinose, backwardly-directed hairs.

The colour of the setae is flavescent, becoming light brown distally.

Gills (Text-Fig. 58)—Pairs of gills occur, inserted laterally, on the first seven abdominal segments.

The gills become larger in size posteriorly as far as the fourth pair; then progressively smaller; those of the first abdominal segment are by far the smallest.

At intervals, the first five pairs are vibrated rapidly, the sixth pair very slightly, the seventh pair not at all.

The first pair are held vertically over the points of insertion, the lamella surfaces facing anteriorly and posteriorly. The other pairs are inclined more and more laterally, i.e., downwards, so that the main tracheal branches of the gills are almost horizontal; at the same time, the gills are directed progressively backwards and also the gill surfaces of posterior pairs become tilted so that their upper edges are thrown backwards, the lower edges forward. The lamellae are ovate with rounded distal edges; their edges are finely-toothed in the upper

distal portion and bear minute hairs all round, except in a small upper proximal section.

The venation is black, pinnate, and well ramified. Below the main tracheal branch, a thick, chitinised, curved band runs longitudinally throughout the gill. It is conjectured that this acts as a brace, strengthening the lamella.

Occasionally in this and other nymphs, an abnormally small gill is found on some segment, in place of one of the normal size: this rather suggests that gills may be regenerated between ecdyses.

Legs (Text-Fig. 57)—Alike: short: robust.

The femora are one and a half times as long as the tibiae, which are slightly longer than the tarsi.

Femora—Short and stout: greenish-white with olive markings distally. Anterior surfaces covered with short spines and a few hairs.

Tibiae—Almost colourless: covered with short spines and a few hairs; the latter are more numerous on the dorsal edges.

Tarsi—Light brown at proximal end; median part with only a tinge of brown; distal end very dark brown. Covered with numerous short spines and a few hairs; the dorsal edges, more especially distally, are noticeably haired.

Claws—Brown, curved, prominent. There are a number of very small teeth on the under-side of each claw.

Ameletus flavitinctus Tillyard.

"IMAGO—female.

"*Total length*—18 mm.

"*Head* (somewhat shrivelled)—Small, dull medium brown; eyes, dull blackish.

"*Thorax*—Pro- and meso-thorax rich umber brown above; meta-thorax dark chocolate brown above; sides dull brown shading to pale brown beneath; mesonotum with two blackish marks placed close up on either side of the median suture posteriorly. Legs short, pale brown, the femora with a broad black median band and a narrower black band at apex; tibiae marked with black apically; tarsi blackish, except for the bases of the first three segments, which are pale brownish. Text-Fig. 20g shows the tarsus of the hind leg, for comparison with that of *Ameletus ornatus* (Text-Fig. 20h), an insect of somewhat smaller size but with much larger legs.

"*Abdomen* narrow, sub-cylindrical, tapering posteriorly. Segments 1-6 dark brown, heavily marked with dull-blackish in the form of a transverse basal band, from which project two elongated, longitudinal marks, one on either side of the median line, and reaching to within a short distance of the apex of each segment; 7-8 paler brown, with similar blackish basal band, but with shorter longitudinal projecting marks, reaching only about half-way along each segment; 9 pale brown, with very narrow blackish basal band and slender longitudinal projecting markings; 10 pale brown, with narrow blackish basal band and no marks. Ventral valve cleft in middle, its margin forming two rounded lobes (Text-Fig. 20f); those of the other New Zealand species are shown for comparison in Fig. 2, d, c. Cerci (partially shrivelled) somewhat longer than abdomen, brown, with darker segmental rings. Appendix dorsalis much reduced, only 3 mm. long, much shrivelled, with numerous minute obsolescent segments.

"*Wings* (Plate 59, Fig. 17)—Forewing, 19.5 mm.; hindwing, 7 mm.; expanse, 41 mm. Wings brilliant, most of the membrane a pale transparent yellowish, but with certain areas absolutely hyaline." ... "where the very irregularly-placed cross-veins lie farthest apart. Veins blackish. Forewing with two groups of thickened black cross-veins between Sc, R1, and R2, one set being

about half way along the wing, the other below the proximal part of the pterostigma. There is a series of five definite spots or bullae on the forewing, on Sc, R1, R2, R3 and R4 respectively, the first three being large and situated in the midst of the first set of thickened cross-veins already mentioned, while the last two are smaller and situated below them. In shape the forewing is similar to that of *A. ornatus*. Hindwing with the humeral angle as shown in Text-Fig. 20c; the same portion of the hindwings of *A. perscitus* and *A. ornatus* are shown for comparison in Fig. 2a, b.

"*Locality*—Stream above high waterfall at Wahi, near Tokaanu, southern end of Lake Taupo, 26th November, 1919 (R.J.T.)." (Tillyard).

From specimens caught this season (1929/30), it has been possible to supplement this description—

SUB-IMAGO.

Wings (Pl. 59, Fig. 18)—Shape and venation as described for imago. Wing-surface with greenish-brown tinge; costal and subcostal areas clear yellowish-green: veins yellow at edges, black centrally: cross-veins edged irregularly with greyish-brown, forming dusky areas in parts and notably two dark zig-zag bands as in *Atalophlebia versicolor*. The dark areas are most numerous in the posterior part of the forewing and the distal part of the hindwing. Abdomen as in imago but with greenish tinge, the eighth tergite is much lighter than the others and this makes it conspicuous, the ninth and tenth are much darker. The lighter parts of the legs are greenish, not brown as in the imago.

IMAGO.

Male as female, with the following differences: Length (excluding setae), 14 mm.; forewing, 16 mm.; hindwing, 5 mm.; wing expanse, 36 mm.

Eyes green. Genitalia (Text-Fig. 68)—Claspers flavescent, becoming dingy distally, four-segmented, the basis obliquely truncated pos-

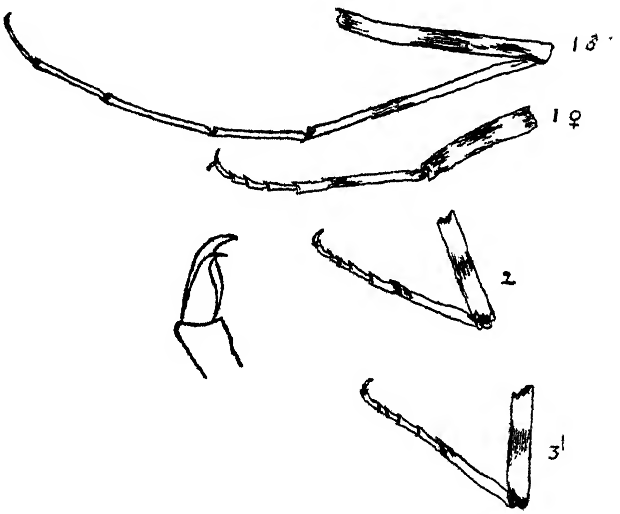


FIG. 67.—*Ameletus flavitinctus*:
Legs of male imago and female forelegs. × 8.

teriorly at each side but nearly straight medianly. Penes flavescent, pointed apically but not so narrow nor so wide as in *A. ornatus*. The legs (Text-Fig. 67) are illustrated and also the wings of the female imago. (Pl. 59, Fig. 17).

Nymph.

The nymph of this species closely resembles that of *A. ornatus*, but it is dark brown in colour and somewhat larger, being about 25 mm., when fully-grown. The abdomen becomes noticeably broader in the middle, before tapering posteriorly and the venter is dingy brown, not white as in *A. ornatus*. The legs have all their segments heavily marked with dark brown.

Besides the locality previously mentioned, I have found this insect in the Whakatiki and Little Wainui Rivers, Wellington district, and in the Gowan River, Nelson district.

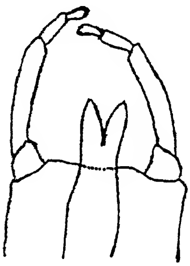


Fig. 68.—*Ameletus flavitinctus*: Genitalia of male imago. × 25.

Genus Ameletopsis, n. g.

One other insect has been included hitherto in the New Zealand *Ameletus* spp. as *A. perscitus*, but for the reasons given below in the description of the species, I have placed it in a new genus.

Tillyard (6) had already suggested that this might have to be done and in a recent private letter suggested *Ameletopsis* as the name he would himself have used had he been able to carry on his work in New Zealand and acted on his tentative opinion that a new genus was necessary.

A comparison of the generic characters of *Ameletopsis* with those of *Ameletus* is also included.

Characters.

Adult—Foreleg of male longer than the body.

Claws mutually dissimilar in each tarsus, the one narrow and pointed, the other broad and blunt.

Tibiae of hinder legs longer than tarsi.

Hind tarsi with four freely-movable segments, the basal one being fused with the tibia.

Eyes of the male approximated.

Median caudal seta rudimentary.

Outer caudal setae of female only half as long as those of male.

Posterior prolongation of the sternum of the ninth abdominal segment of female emarginate at tip.

Claspers of ♂ Genitalia three-segmented.

Cubital and anal veins divergent distally.

Numerous intercalary veins between Cu 1 and Cu 2. (Tillyard notation), many of which are unconnected proximally.

Veins IM forks proximally, the ends running into M 1 and 2 and M 3 and 4.

Veins and cross-veins very numerous and regularly spaced in the forewing.

Veins and cross-veins particularly numerous near the posterior margin of hindwings, forming a network of elongated cells in the area of the tornus.

Costal dilation of hindwing very obtuse.

Nymph—Structure adapted partly for swimming, partly for creeping. Body more or less flattened dorso-ventrally; head in much the same plane as body.

Caudal setae short, sub-equal, fringed with hair on both sides; three in number.

Gills on first seven pairs of abdominal segments, consisting of large, round, entire, single, simple leaflets with central pinnate trachea.

Latero-posterior angles of abdominal segments prolonged backwards as sharp teeth.

Eyes of male unlike those of female.

Legs alike and sub-equal.

Mouthparts strongly developed; canines very long; palps multi-articulate.

Imago—Notae eadem quae Ameleti his exceptis.

Seta media caudae rudimentaria; setae exteriores feminae in longitudine dimidio minores quam maris. Prolatio posterior sterni segmenti noni abdominalis ad extremitatem emarginata.

Venae venulaeque transversae numerosissimae et in a la anteriore ordinatim dispositae.

Prolatio costalis alae posterioris obtusissima.

Larva—Tres setae caudales braves et quasi aequales utrimque capillis fimbriatae.

Paria branchiarum septem; unum quodque folium orbiculatum cum trachea media pinnata.

Anguli exteriores posteriores segmentorum abdominalium retro prolati denticulatique.

Crura similia et subaequalia.

Oris partes maxime dilatatae; dentes canini longissimi; palpi multis articulis.

Imaginal Characters.

Genus Ameletus.	Genus Ameletopsis.
Median caudal seta completely aborted (Eaton, *T.L.S.* 1888, p. 210). Revis. Monog. on Recent Ephem.	Median caudal seta rudimentary.
Outer caudal setae as long as body in both sexes. (Eaton, *op. cit.*, p. 210).	Those of ♀ only half as long as ♂.
Genital forceps four-segmented.	Genital forceps three - segmented.
Posterior prolongation of the sternum of the 9th abdominal segment of ♀ entire at tip. (Needham, p. 25, Key to Genera, May-flies of N. America, *N.Y.S.M. Bull.* 58).	Emarginate at tip.
Femora with heavy dark bar medianly.	Femora *without* dark median bar.
Tarsal claws alike in each leg.	Tarsal claws dissimilar.
Wings — Intercalaries between A_1 and A_2 of forewing (i.e., Cu_1 and Cu_2, Tillyard's notation) represented by a series of veinlets often sinuous or forking, extending directly from wing margin to Cu_1. (Needham, p. 25, *op. cit.*).	A number of the intercalaries start from the wing margin but do not extend as far as Cu_1.
Vein IM of forewing, unconnected proximally.	Vein IM forks proximally, the branches running into M_1 and $_2$ and M_3 and $_4$.
Cross-veins of ptero-stigmatic region simple.	Cross-veins of ptero-stigmatic region reticulate.
Veins less numerous and more irregularly-spaced.	Veins very numerous and regularly-spaced in the forewing: in the hindwing they are particularly numerous near the posterior margin so that the tornus area appears a network of elongated cells.
Costal dilation of hindwing nearly right-angled. (Eaton, p. 201, *op. cit.;* Needham, p. 25, *op. cit.*).	Costal dilation of hindwing very obtuse.

Note.—The notation of the veins, except where otherwise stated, is that of Tillyard.

Ameletopsis perscitus (Eaton).

IMAGO.

Length (excluding setae)—18 mm.

Head—Light lemon yellow with a burnt-umber area between the eyes and a like-coloured longitudinal median line down frons. Eyes of female, buff; of male, buff below, yellow above. Ocelli, greenish-black.

Thorax—Light yellow with burnt-umber areas dorsally and ventrally.

Abdomen—Ground colour fawn, with burnt-umber median markings on the first nine segments. On each segment the markings resemble a bell, which becomes thinner successively on posterior segments. The 'clapper' is represented by a light yellow dot on the first seven segments. On the eighth and ninth segments, it is not visible. The tenth has no brown marking, but a rounded median posterior projection. Posterior lateral angles of the ninth segment project backwards markedly, those of the tenth slightly. Venter pale yellow. Claspers (Text-Fig. 77) pale yellow, three-segmented. Penes pale yellow, closer together than in *Ameletus.* Caudal setae flavescent, grey at joinings: outer ones—male, 22 mm.; female, 12.5 mm.: median one—male, 3 mm.; female, 2 mm.

Legs (Text-Fig. 76)—Femora and tibiae lemon yellow, lightly tipped with grey distally: fore-femora slightly darker than the others. Tarsi five-segmented; first four segments flavescent, tipped with grey distally; fifth joint greyish.

Wings—Expansion—male, 33 mm.; female, 40 mm. Surface brilliant yellow: veins black except Sc, R_1 and R_2a, which are flavescent: cross-veins pitch black and very numerous, especially round the wing-margin, those in the ptero-stigmatic region are reticulate. Bullae on Sc. and R_2a.

SUB-IMAGO.

Wings (Pl. 60, Fig. 21)—Semi-opaque, brilliant yellow. There are three greyish blobs, in line longitudinally, in the anterior-distal part of the forewing, the proximal blob being about half way along the wing from wing-base.

The sub-imaginal stage lasts two or three days.

The winged stages appear from the end of December to March.

NYMPH.

The nymph (Pl. 59, Fig. 19) of this mayfly is unique in many respects. Its structure differs so markedly from that of the genus *Ameletus* and moreover from that of the Sub-family to which this genus belongs, that there can be little doubt that it has been incorrectly placed.

Indeed Tillyard (6), in his description of *Ameletus flavitinctus,* states:

> "It seems advisable here to point out that *A. perscitus* Eaton differs very greatly from both *A. ornatus* Eaton and *A. flavitinctus* n. sp. in the shape of its wings, the density and regularity of their cross-

venation, and in the remarkable structure of its large-headed larva. These characters, taken together, suggest that it is not really congeneric with them. Further than this, a study of the three New Zealand species shows that they differ considerably from the genotype, *A. subnotatus* Eaton, from North America, and it appears probable that they may have to be placed in two new genera."

Hitherto, the larva does not appear to have been described, studied and compared with other larvae of the same genus, and the only notes on it are a few lines by Eaton (5), p. 291, and Hudson, *N.Z. Neuroptera*, p. 40.

Needham (8) considers the mayflies to be a single family, and divides them into three sub-families, whereas Lestage (10) ranks them as an order and groups them in five families. However, Needham's sub-family Baetinae corresponds very closely to Lestage's family Baetidae—*not* to be confused with his sub-family Baetinae, for it is to his sub-family Siphlurinae that he assigns the genus *Ameletus*. Needham has no subdivision corresponding to this.

The species under discussion, *A. perscitus*, can be included in Needham's sub-family Baetinae or alternatively Lestage's family Baetidae, but that is as far as we can go. It cannot be included in Lestage's sub-family Siphlurinae, to which he assigns the genus *Ameletus*, for this sub-family has the outer caudal setae fringed internally only, whereas *A. perscitus* has them fringed on both sides. It does not agree with his generic characters for *Ameletus*, in that the head is not vertical but horizontal, the external edges of the gills are not toothed or haired but smooth and their ramification is considerable—not little ramified; moreover, the palps are not 3-jointed but multi-articulate: this, by the way, takes it out of Eaton's nymphal groups (p. 317 (4)) on which most of the work of Lestage and Needham is based, and puts it in a group with his unknown Chilian nymph, to which alone the mouth-parts of *A. perscitus* bear some resemblance, but the structure of other parts of these two are totally different.

Needham, also, groups various genera, among which is *Ameletus*, as having the outer caudal setae fringed only on the inner side, and also states that the end of the maxillae are fringed with pectinated hooks. *A. perscitus* does not correspond to this description.

In addition to these differences, the extraordinarily developed mouth-parts and the shape of the head and also, the insect's curious habits are quite unlike those of any species of *Ameletus* and indeed those of any other mayfly nymph.

Description of Nymph.

Length—Ca., 2 cm.

Head (Text-Fig. 69)—This is sub-rotund, anteriorly, and extremely large in proportion to the body; the posterior margin is straight. The head of the male is shorter than that of the female.

Antenna—About as long as the head; subulate; flagellum 18-jointed. They are extended outwards in front of the head at an angle of about 45 degrees.

Eyes—female—Brownish-black, oval with longer axis running anteriorly-posteriorly; *male*—sub-rotund, more approximated than in

Fig. 71

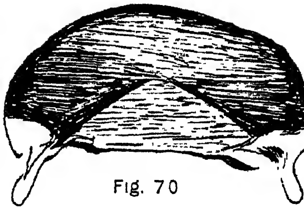


Fig. 70

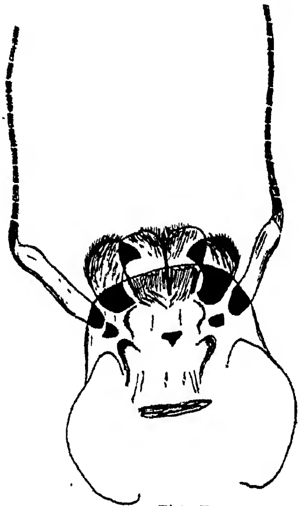


Fig. 72

Fig. 73

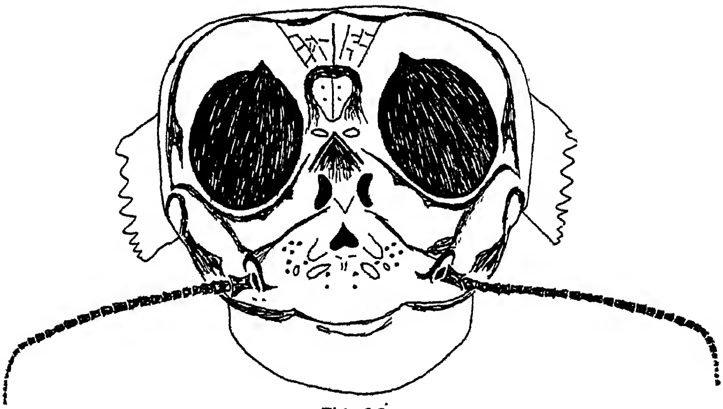


Fig. 69

Nymph of *Ameletopsis perscitus.*

FIG. 69.—Head. × 16.
FIG. 70.—Labrum. × 20.
FIG. 71.—Left mandible. × 20.
FIG. 72.—Labium and hypopharynx. × 20.
FIG. 73.—Left maxilla. × 20.

the female, each eye consisting of a green upper and proximal portion and a dark brown lower and distal portion; this latter portion is the larger. Occasionally, the upper portion is light brown, and the lower portion white. Both parts are composed of numerous small facets. In each case, the margin of the outer half is more or less regularly rounded, whereas the curve of that of the inner half becomes a rounded angle medianly; this angle is more pronounced in the upper portion of the eye than in the lower.

Ocelli—Brownish-black; cordate.

Labrum (Text-Fig. 70)—Rounded anteriorly; this margin has a fringe of very short hairs. Umber-brown, glabrous, covered with minute pits on both dorsal and ventral surfaces.

Mandibles (Text-Fig. 71) — The canines are extraordinarily developed and the molar portion seems to be aborted. The armature, which has an inward curve, is as follows: Distally is a heavily-chitinised, unsymmetrical, incurved, bifid fang, of which the outer limb is the longer. Next is a similar somewhat smaller sharp tooth, straight, but sloping inwards and somewhat pyramid-shaped, and finally a lobe with a chitinised, acuminate tip, considerably shorter than the tooth exterior to it. The interior (i.e. proximal) margin of the lobe, as well as both surfaces, is armed with stout, sharp, long, luteous spines. This lobe, with its spines, represents the prostheca.

Maxilla (Text-Fig. 73)—The lacinia terminates in five long, chitinised, incurved, spinose teeth, of which the inside one is smaller than the others. The stipes is dull white, dingy in places and covered with small pits. Palp subulate, light fawn, 15-jointed, the second joint longer and broader than the others (the one illustrated has lost its terminal two joints).

Labium (Text-Fig. 72)—Palps very long and held extended in front of the head; they are 19-jointed, the basal joint being three times as broad and nearly half as long as the flagellum formed of the 18 other joints. Paraglossae broadly falcate, pilose, not quite as broad as the internal lobes. Glossae sparsely haired, sub-quadrangular with their exterior-anterior margins rounded in an arc, the interior ones with only the corners rounded.

Hypopharynx (Text-Fig. 72)—Almost colourless, glabrous, covered with small pits. Superlinguae gently rounded anteriorly and projecting straight forward.

Thorax—Sepia-brown mottled with yellow, with chestnut tinge in the median area. There is a thin light median line. Pro-thorax and meta-thorax short and wide; meso-thorax same width but longer than both combined. Wingpads are comparatively small and coloured dusky olive.

Legs (Text-Fig. 74)—Sub-equal, but the third pair of tibiae is slightly longer than the other two pairs. Pale yellowish-brown, sometimes with greenish tinge, with thick median bars of dark brown on the femora and tibiae and another spreading over the proximal half of the tarsi. Surface glabrous, covered with minute pits. Rows of hair on the ventral side of tarsi and tibiae; Tarsal claws yellow, dilated at base, acuminate but not hooked; not toothed.

Abdomen—dorsal—Each segment (Text-Fig. 75) has a chitinised plate which is sepia-brown, mottled with yellow (as figured) and be-

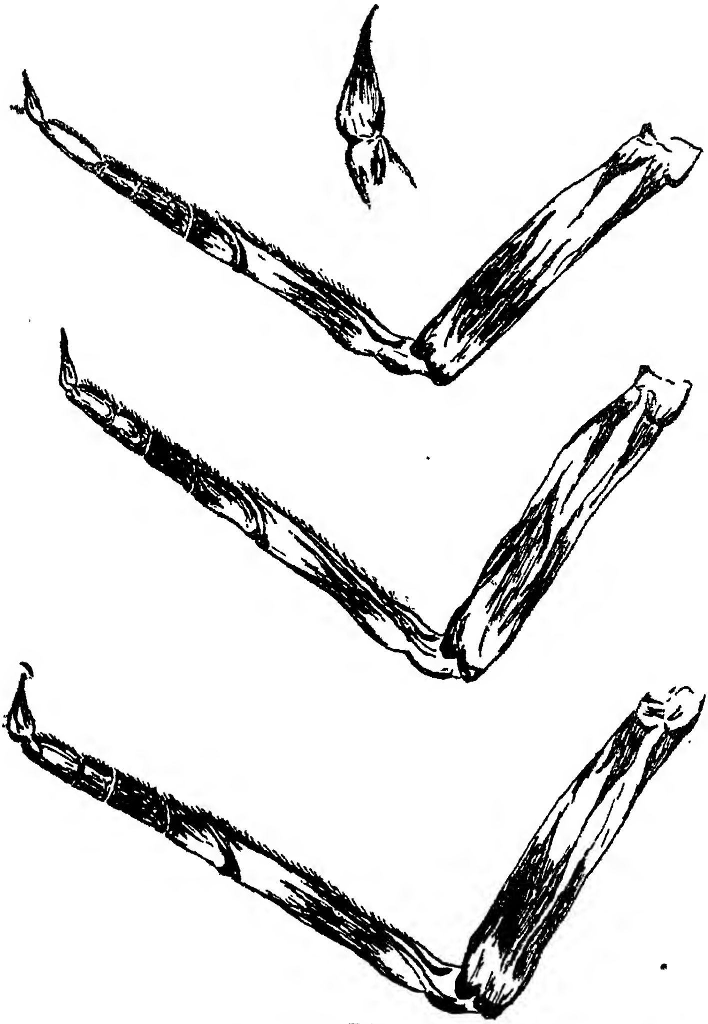
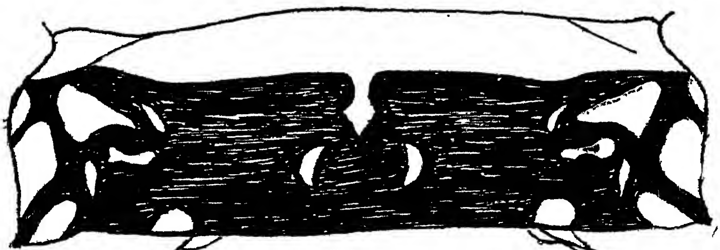


Fig. 74

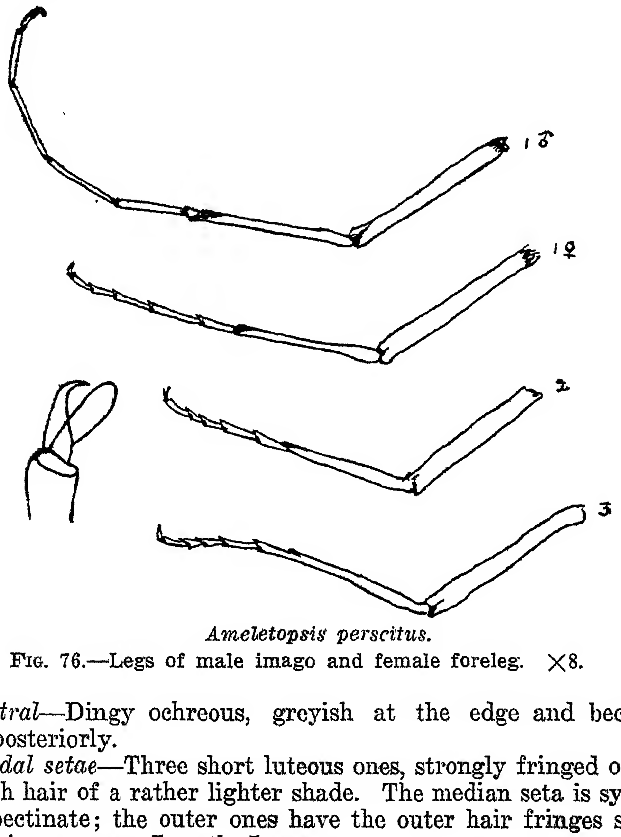


Fig, 75

Nymph of *Ameletopsis perscitus.*

FIG. 74.—Legs. × 20.
FIG. 75.—Dorsum of sixth abdominal segment. × 20.

tween these plates are narrow, non-chitinised strips, which are yellow with a pair of burnt-umber median markings (not shown in segment illustrated). Comparatively wide; the fourth and fifth segments are the widest and from these it tapers posteriorly. The latero-posterior angles of segments are produced backwards into sharp teeth, the angles of the ninth segment being particularly acuminate. The posterior edge of the tenth segment first slopes slightly forward from the exterior angles and then curves more sharply backwards to a median truncation; it carries a row of short and very small spines pointing backwards, as does the posterior edge of the ninth segment, which is concave. The sixth dorsal segment is illustrated. Younger specimens are much paler, the brown being replaced by yellow.



Ameletopsis perscitus.
FIG. 76.—Legs of male imago and female foreleg. ×8.

Ventral—Dingy ochreous, greyish at the edge and becoming darker posteriorly.

Caudal setae—Three short luteous ones, strongly fringed on both sides with hair of a rather lighter shade. The median seta is symmetrically pectinate; the outer ones have the outer hair fringes shorter than the inner ones. Length, 5 mm.

Gills (Pl. 60, Fig. 20)—Seven pairs of very large single leaf-like, rounded gills on the first seven segments of abdomen. Their edges are entire and the anterior edge of each is strengthened with a rib. They are fairly frequently vibrated but held still for considerable periods. The first pair are held upright (edges upwards) over the body, the second pair nearly so; the remaining pairs are held obliquely outwards. The venation is pinnate with a stout central trachea and many branches, frequently much ramified.

I am indebted to Capt. Hayes, of the Marine Department, Wellington, for the drawings of the gills, the first three from a half-grown specimen, the fourth from a full-sized one.

Habits—This nymph is carnivorous, feeding on small specimens of Leptophlebiid nymphs and other organisms.

Though found under stones in rapid water, its favourite haunt is some dark still backwater or a shallow, slowly-flowing portion at the edge of a stream. Here it will lie perfectly still on a stone or in a crevice, except for an occasional movement of the gills, its camouflage colouring making it very difficult to detect. At times, it will walk forward with a gliding motion for a few inches, ' freeze ' for

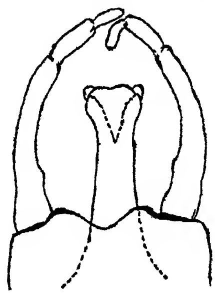


FIG. 77.—*Ameletopsis perscitus.* Male imago, genitalia. × 25.

some seconds, and then move forward again. It has a habit of brushing its mouth-parts with its anterior pair of legs. Another characteristic is its trick of peering cautiously round the edge of a stone and stalking slowly forward.

Though sluggish, when thoroughly disturbed it can move with considerable rapidity, swimming strongly with quick, somewhat jerky movements of its body.

It becomes full-grown from December to March, when it crawls on to a stone above water-level to transform to the sub-imaginal stage.

It occurs throughout the Wellington district, moderately distributed, and I have also found it in Hawkes Bay and in Canterbury.

ACKNOWLEDGMENT.

I am very greatly indebted to Professor H. B. Kirk, of Victoria University College, Wellington, for much help and for his kindness in reading over this paper; to Dr. D. Miller, of the Cawthron Institute, Nelson, for encouragement and for the loan of literature, otherwise inaccessible; to Dr. R. J. Tillyard for a number of valuable suggestions; to Professor E. Percival, of Canterbury College, Christchurch, for the information concerning the seventh gill of *Oniscigaster;* to Capt. L. Hayes, M.C., of the Marine Department, Wellington, for the drawing of the gills of *Ameletopsis perscitus* and for much help in collecting; to Mr. G. V. Hudson for the loan of valuable literature; to Mr. A. Waterworth for the microphotographs, and to Mr. H. Drake for the excellent photos. of the winged stages of *Oniscigaster intermedius.*

The opportunity for doing this work was provided by the Wellington Acclimatisation Society, who most generously provided a three-year grant for a Fellowship in Fresh-water research.

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A Revision of New Zealand Ephemeroptera.

PART 2.

By CAPT. J. S. PHILLIPS, M.C., M.A. (Oxon.), F.R.G.S.

[*Issued separately, 30th August, 1930.*]

PLATES 61–67.

CONTENTS.

IN this paper, it is proposed to deal with the species of families other than those of EPHEMERIDAE and SIPHLONURIDAE.

According to Tillyard's Australasian classification (7), there remain the LEPTOPHLEBIIDAE and the BAETIDAE.

So far, no species belonging to the latter family has been found in New Zealand; this leaves the LEPTOPHLEBIIDAE.

One or two of the species, described herein, have not been worked out in all stages, but owing to the fact that there will be no opportunity of studying the members of this family in their habitat, in the near future, it was thought better to publish the data available rather than to defer doing so to an indefinite date.

When time and opportunity permit, it is hoped to supplement the information contained in these two papers by the publication of a third.

Family LEPTOPHLEBIIDAE.

This family, which contains mainly the smaller mayflies, comprises more than half the species in New Zealand. Some of them are very much alike and hard to distinguish from each other, and it will probably be a considerable time before all the species in this country have been identified and described.

Although, as in most of the Ephemeroptera, the best time to secure the winged stages is on a fine summer evening, yet individuals of this family hatch out at various times of the day throughout the year, even in midwinter, in the Wellington district.

The family now includes thirteen New Zealand species. Two genera have been recognised—*Atalophlebia* Eaton (1881) and *Deleatidium* Eaton (1889).

These genera are distinguished from each other in the nymphal stage, in that *Atalophlebia* has double gills, whereas *Deleatidium* has single ones; in the adult stage, they may be differentiated by the tarsal claws, which in the former genus are alike in each tarsus and in the latter one dissimilar, i.e., one claw is narrow, hooked and pointed at the apex, the other is broad and blunt.

Two of the newly-discovered species, namely, *D. sepia* and *D. cromwelli*, were first believed to belong to the genus *Atalophlebia*; the modus operandi was to breed the flies from the nymphal stage in the aquarium, and these two had the nymphal characteristics of that genus, e.g., double gills.

It was found later, however, that the flies had unlike claws in each tarsus, and this adult character had been chosen by Eaton to differentiate a new genus *Deleatidium*, whose nymphs, however, had single gills.

Thus we had two new species with the adult characters of *Deleatidium* and the nymphal ones of *Atalophlebia*.

Obviously the original distinguishing features are inadequate, but in view of the fact that no really satisfactory substitutes have yet been found and, even more, because the allied species in Australia have not yet been described in all stages—and they may clarify the situation—and lastly because there are almost certainly still more species in New Zealand undiscovered, it has been thought advisable not to reclassify at present, but to place these two disturbing species temporarily in a sub-genus *Atalophlebioides* of the genus *Deleatidium*.

To assist in identification, this sub-genus has also been included in the Key to Species of the genus *Atalophlebia*.

"*Adult.*—Forewing with tornus more or less well marked, always close to base (at one-fourth of wing-length from base or less) in correlation with the greatly reduced hindwings. *Cu 1* attached to *M* at a point just beyond its origin and very strongly angulated there; branches of *Cu 1* few; *Cu 2* sigmoidally curved, ending not far short of tornus; anal veins much reduced. A bulla usually present on *R 2a* about half way along the wing." (Tillyard (7)).

Nymph.—Nymph of the crawling type: body more or less flattened dorso-ventrally. Eyes lateral. Antennae long and filiform. Mandibles short, not extending in front of the head. Maxillary and labial palps three-segmented. Galea-lacinia of maxilla terminating apically in a broad brush of brown hair and a number of minute pectinate rakes. Wing-pads generally prominent. Legs long, spinose: femora oval: claws toothed underneath. Latero-posterior angles of segments of posterior half of abdomen toothed backwards. Caudal setae long, median one usually slightly the longest: whorled on both sides with very short hairs. Gills borne laterally on the first seven abdominal segments, sometimes alike and then double, either in the form of a bifid lash or a pair of ovate-acuminate lamellae, sometimes dissimilar and then the gills are single and those of the first pair are kidney-shaped in outline and those of the remaining pairs are round or ovate.

Genus ATALOPHLEBIA Eaton (1881).

"*Adult.*—Hindwing in front somewhat arched, the summit of the arch obtusely sub-angular, situated usually before the middle of the curve; sub-costa strongly arched, meeting the margin very obliquely; radius usually nearly straight, constituting as it were the chord of the arch described jointly by the sub-costa and the portion of the margin included between its extremity and the radius; hence, while the narrow marginal area is broadest at the base and acuminate at its termination, the sub-marginal area is broadest at the middle, or a little before the middle, and tapers gradually to its oblique apex. Cross veinlets abundant in the forewing, those in the marginal area before the bulla well-defined. At the terminal margin the longitudinal nervures are provided with curved simple branchlets, and there are no isolated veinlets. The two intercalar nervures of the anal-axillar interspace of the forewing have simple branchlets, and usually the hinder one, close to its proximal extremity, curves forwards to unite with the other, which similarly curves forwards to join the anal nervure; occasionally, especially in female specimens, a cross veinlet is transferred from near the wing-roots to establish communication between the first axillary and the anterior intercalated nervure; less frequently, this last nervure annexes itself to the first axillary." .... "Guard at the orifice of the mesothoracic spiracle small and triangular. Forceps limbs of male three-jointed; the proximal joint much longer than the remainder, somewhat compressed, and in its basal half broadly dilated beneath; the deflexible basis, usually prominent in the middle of its distal border, is otherwise merely emarginate; the corresponding lobe in the female, usually bifid and sharply excised with acute triangular points, is seldom emarginate only. Segments 6-10 constitute about half the abdomen; segment 8, the longest, is nearly equalled by segment 7; the others are successively shorter. Median caudal seta about as long as the others, seldom thrown off by specimens; outer setae, in both sexes, usually double (in some cases treble) the length of the body. Tarsal ungues all nearly alike, small, narrow, and hooked at tip. In normal species the male fore-tarsus is nearly as long as the tibia, or a little longer than it, and the latter is about 1⅓ as long as the femur; the female fore-tarsus is nearly half the length of the tibia, and this about 1⅓ as long as the femur; in both sexes the tarsal joints, arranged in diminishing succession, rank thus: 3, 2, 4, 5, 1. Hind-tarsus usually about half the length of the tibia." (Eaton).

Nymph (characters applicable to New Zealand species).—Nymph of the crawling type. Body somewhat flattened dorso-ventrally. Eyes lateral. Antennae long and filiform. Maxillary and labial palps three-segmented. Labrum always less than three times as broad as it is long and notched medio-anteriorly. Maxilla with broad terminal brush of long brown hairs and small pectinate rakes. Wing-pads large. Legs long, spinose: femora usually somewhat dilated: claws toothed underneath. Latero-posterior angles of abdomen mostly toothed backwards, pronouncedly so in the posterior half. Caudal setae of varying length, minutely haired at segmental joinings; median seta longest. Pairs of gills borne laterally on the first seven abdominal segments: the gills are double and consist each of a double lash or a pair of lanceolate or ovate-acuminate lamellae: venation generally pinnate. The gills of the posterior pair are often aborted.

As New Zealand *Atalophlebiid* nymphs do not appear to have been described before, in any detail, the opportunity is taken of pointing out that they do not agree in some particulars with the characteristics assigned to *Atalophlebia* by Needham and Murphy (9), for example: 'Posterior-lateral angles of rear abdominal segments not tipped with thin flat lateral spines...' On the contrary, our nymphs have teeth or spines on these segments, notably *A. cruen-*

tata. Again, . . . ' Femora regularly tapering from near the base, not dilated. . . .' In our species, the femora *are* generally dilated and the broadest part is at, or near, the middle of this segment. Further, the labrum could hardly be described as ' narrowly elliptical ' and the acute median notch in front is sometimes a slight curved indentation.

On page 36, *op. cit.*, however, there is a conflicting description of *Atalophlebiid* nymphal characters and they are described as having lateral spines on abdominal segments five to nine and the femora as being dilated.

The other characters, specified on this page, do not agree with the characters of our species, i.e., the distal tooth under the tarsal claw is *not minute*—compared with the others—but slightly larger, the width of the labrum does not exceed the length three times, but is not quite twice as long and the glossae are not conic-pointed in our species.

Keys to N.Z. Species of Atalophlebia.

Adults.

A. Wing expanse one inch or more—	
1. *Costal region of hindwing orange-red: fore-femora with dark median transverse bar*	*A. cruentata* Hudson Page 347
2. *Not as above*—	
(*a*) Femora luteous: Abdomen light brown, first 8 segments dark-rimmed posteriorly. Egg irregularly oval	*A. dentata* (Eaton) Page 344
(*b*) Femora olive-brown or burnt-umber: Abdomen very dark-olive-brown: Egg spindle-shaped	*A. versicolor* (Eaton) Page 339
B. Wing expansion less than one inch—	
1. *Anterior femora with dark median transverse bar*	*A. nodularis* (Eaton) Page 352
2. *Anterior femora without bar*	Sub-genus **Atalophlebiodes*
(*a*) Tarsi brownish-grey	*D.* (*A.*) *sepia*, n. sp. Page 383
(*b*) Tarsi almost colourless	*D.* (*A.*) *cromwelli*, n. sp. Page 385

Nymphs.

A. Nymph orange-red in colour	*A. cruentata* Hudson Page 347
B. Nymph dark-coloured—	
(1) *Caudal setae as long as or longer than body*	
(*a*) Femora oval—	
(i) With bold, black markings on first nine abdominal segments, both dorsally and ventrally	†*Atalophlebia* ? n. sp. Page 356

*Flies hatching out from apparent *Atalophlebid* nymphs, yet having the claws of the adult dissimilar in each tarsus. This sub-genus is, at present, included under the genus *Deleatidium* (see page 358).

† Winged stages not known, and therefore not included in Key to Adults.

(ii) With light yellow median longitudinal stripe on dorsum: femora with two dark sinuous bands ... ... *Atalophlebia versicolor* Eaton Page 339

(iii) Dorsum not as above: femora greatly dilated, grey with a light yellow patch at each end and two in the middle ... *Atalophlebia dentata* (Eaton) Page 344

(*b*) Femora sub-parallel ... ... *D.* (*A.*) *cromwelli*, n. sp. Page 385

(2) *Caudal setae shorter than body.*

(*a*) Legs almost colourless: gills seldom vibrated ... ... *Atalophlebia nodularis* (Eaton) Page 352

(*b*) Legs mottled: gills actively vibrated ... *D.* (*A.*) *sepia*, n. sp. Page 383

Atalophlebia versicolor Eaton.

Imago.—*Length* (excluding setae)—12.5 mm.

Head—Reddish-brown with black markings. Eyes of female and lower lobes of those of male, greenish-brown; upper lobes, raw-umber. Ocelli, greenish-brown.

Thorax—Raw-umber.

Abdomen—Burnt-umber or bistre-brown: the segments have outward-curving crescent-shaped marks on each side of the median line: the tenth segment is much lighter. Venter somewhat lighter. Penes "bistre-brown: lobes contiguous to one another; concave beneath towards the line of contact, upcurved, narrowed and sloped off towards their truncate tips. Claspers basal joint compressed, narrowed somewhat suddenly after the acute end of the inferior dilatation. Bistre-brown. Caudal setae medium, warm sepia brown, with the distinct joinings blackish; some of the alternate joinings indistinct or not coloured." (Eaton) (5)).

Medaian one—male, 27 mm.; female, 18 mm.; outer ones—male, 23 mm.; female, 16 mm.

Legs—Femora olive brown or burnt umber, anterior ones a shade darker than the others: darkened narrowly at each end. Tibiae very light burnt umber. Tarsi fawn, proximal two joints rather lighter: four-segmented.

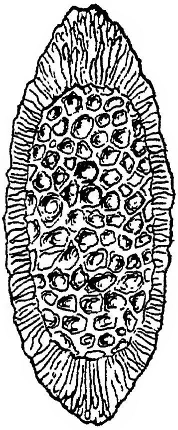
Wings—Expansion of male, 24 mm.; of female, 29 mm.

"Vitreous with black neuration. In the marginal and sub-marginal areas, tinted with transparent raw umber or brown umber cross-veins of the same area narrowly set off with black, showing strongly, and a few of them (both near the sub-costal node, and again midway beyond these towards the apex), suffused by a small dark-greyish cloud that extends from the costa to just below the radius. The cross-veinlets of the marginal area, all simple, number about six before and sixteen beyond the bulla." (Eaton (5)).

A further dark area is found in the pterostigmatic region and there is another very small one at the fork of MA1 and MA2.

Eggs—About 2000 eggs are laid: each egg (illustrated in Pt. 1: Text-Fig. 22) is spindle-shaped, the egg proper being completely surrounded by an adhesive network matrix.

Wings of Sub-Imago (Pl. 61, Fig. 1)—Wing surface dull and colourless, except in the marginal and sub-marginal areas, which are light brown (Eaton (5) says dull reddish-purple) and in certain other areas, irregularly marked with dark grey, notably two conspicuous zig-zag bands, directed forwards and outwards across the wing surface.



Atalophlebia versicolor: Egg. × 320.

Nymph.—This nymph lives among the *debris* in the beds of streams and frequents the more sluggish portions of them.

It is easily captured, being a poor swimmer, moving with a jerky, awkward, undulating motion of the body, agitating the legs rapidly and closing the setae, which are normally held spread at a right angle.

It can, however, edge sideways and retreat backwards with great agility, and when pursued does so, seeking shelter in a crevice or under a stone and seldom attempting to escape by swimming away.

Description.

The body is flattened dorso-ventrally: its length, excluding setae, is 12 to 13 mm.

Head—Quadrangular with rounded corners: yellow with olive brown markings, becoming reddish anteriorly.

Antennae—About as long as head and thorax combined: light olive at base, becoming greyish-brown distally: filiform.

Eyes—Olive brown.

Labium (Text-Fig. 1)—Palp colourless, faintly yellow-tinted apically; three-segmented, terminal segment subulate; the first and third segments are freely covered with spinose hairs; the second is sparsely covered. Paraglossae narrowed at base and suddenly swelling out, each somewhat resembling a pipe with the stem broken off diagonally close to the bowl, which is facing inwards: colourless: profusely haired anteriorly. The outline of the glossae resembles the track of a sheep's hoof, their inner edges in contact with each other,

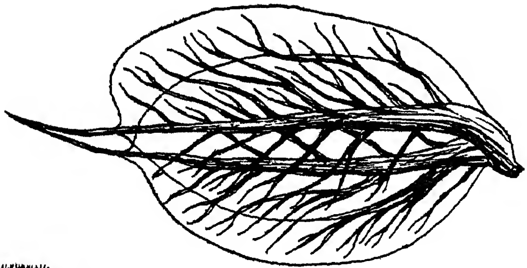


Fig. 10

Fig. 3

Fig. 1

Fig. 5

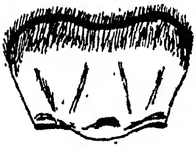


Fig. 6

Fig. 2

Fig. 4

Nymph of *Atalophlebia versicolor.*

FIG. 1.—Labium. × 25.
FIG. 2.—Mandible. × 25.
FIG. 3.—Maxilla. × 25.
FIG. 4.—Maxillary rake, greatly enlarged.
FIG. 5.—Hypopharynx, Ca. × 50.
FIG. 6.—Labrum. × 25.
FIG. 10.—Gill, Ca. × 25.

their outer edges with the paraglossae. The anterior and exterior margins are densely haired, the interior ones have spines only and there are a few spines on the ventral and dorsal surfaces.

Mandible (Text-Fig. 2)—Both outer (o.c.) and inner canines (i.c.) are heavily chitinised and divide into three well-defined teeth apically. The prostheca (p) is chitinised distally and ends in a sharp point: interior to it is a brush of inwardly-directed long bristles. The molar surface (m) is well-developed and bears eight to ten parallel, serrated ridges.

Maxilla (Text-Fig. 3)—Palp three-segmented. All segments are sparsely spined, but the apical one is densely covered distally with long hairs. The maxilla terminates anteriorly in a broad brush of thick brown hair; lying almost concealed among the hairs is half a row of pectinate rakes (Text-Fig. 4): this line of rakes is rooted in the ventral anterior edge of the maxilla and, starting from its proximal corner, spreads half way along the edge. The proximal edge of the maxilla is fringed with hairs, which become shorter and light brown in colour anteriorly.

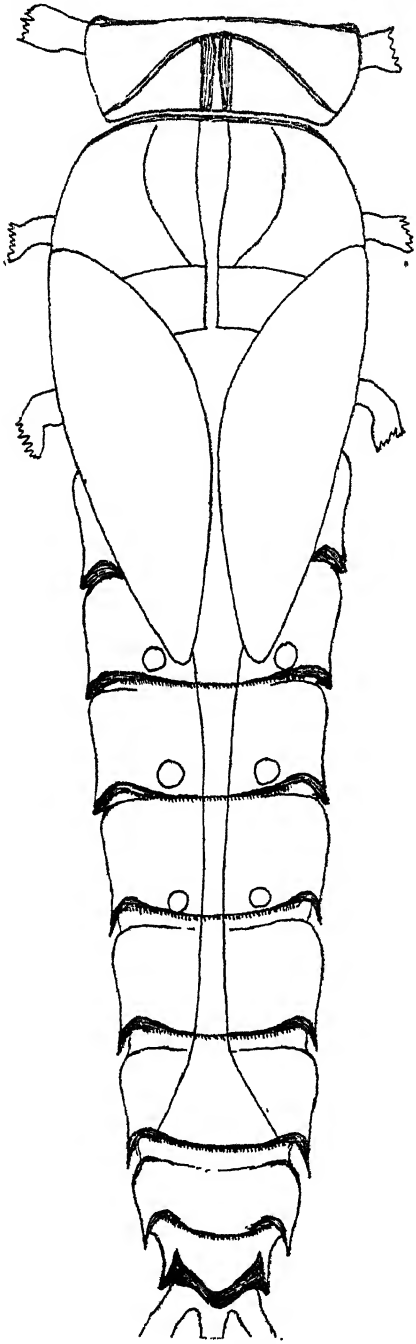
Hypopharynx—Transparent except for slight yellowish tint on anterior border. Median lobe with a few short hairs and small central reentrant in anterior border. The superlinguae (Text-Fig. 5) have strongly curved anterior borders with a fringe of long brown hair: the exterior margins are nearly straight, the posterior ones run parallel to the anterior ones. The hypopharynx as a whole, therefore, resembles a V, with arms curved outwards.

Labrum (Text-Fig. 6)—Yellow: chitinised: exterior-anterior angles rounded. There is a slight inward curve in the middle of the anterior margin, where it is irregularly serrated in places. On both dorsal and ventral surfaces, this margin is bordered with a row of spines with recurved tips, all bent towards the central line, and behind this row is a parallel one, not having recurved tips. Between these rows, on the exterior-anterior bends are other spines, some straight, others slightly curved and most of them directed inwards: similar spines occur scattered throughout the anterior half of both surfaces. In the posterior portion there is a row of inwardly-pointing spines on each side of the median line extending from half way almost to the posterior margin and in the space between the apices of the rows of spines lies a tongue-shaped series of clusters of little hairs; the apex of the tongue is directed forwards. These hair clusters point outwards.

The posterior margin of the labrum has obtusely-angled corners and a gently-curved salient medianly.

Thorax (Text-Fig. 7)—Olive brown with light markings, notably a median line: there are also various small diversely and irregularly-shaped black markings. The pro-thorax is short and wide. The mesothorax is about the same width but twice as long. Wing-pads large and prominent: brownish-black: covering the first four abdominal segments.

Legs (Text-Fig. 8)—The general ground colour is barley-sugar yellow. The third pair of legs is the longest and they have the femora and tibiae longer than those of the other two pairs. The middle pair of tarsi are shorter than the anterior and posterior pairs, which are



Nymph of *Atalophlebia versicolor.*
FIG. 7.—Body-dorsal view × 16.

the same length. In all cases, the tibiae are slightly longer than the femora—noticeably so in the third pair: the tarsi are less than half (in the posterior pair about one-third) the length of the tibiae.

Femora—Dilated very noticeably: the outer areas are translucent; there are two dark brown, irregular and somewhat sinuous bands running transversely. The surface is covered with short spines.

Tibiae—There is a thick dark brown band about the middle. Rows of spines occur on both the dorsal and ventral borders.

Tarsi—A broad dark brown band covers the proximal half of this segment except for a narrow yellow belt at the very end. This band gradually shades off and the distal half is pinkish-yellow. There is a row of spines on the ventral borders.

Claws (Text-Fig. 9)—Curved, with a number of small teeth projecting from the concave surface.

On both tibiae and the tarsi, there are in addition to the spines a few weak hairs.

Abdomen (dorsum) (Text-Fig. 7)—Ground colour olive brown. Posterior-lateral angles of segments 6, 7, 8 and 9 project backwards as pronounced teeth. The posterior edges of segments are minutely serrated. A median yellow stripe runs along the surface, broadening out to the corners like a funnel on the eighth segment: the ninth is yellow as is the tenth, except for a dark posterior rim, olive brown in colour. There is also a pair of light coloured spaces on each segment, placed between the posterior-lateral angles and the median line. In some specimens these are very noticeable, in others hardly discernible, but they are always more marked on the anterior than on the posterior segments.

Venter—Pale ochre with dark median stripe marking position of alimentary tract.

Caudal Setae—Three: median one, 20 mm.; outer ones, 19 mm.: whorls of short hair at joinings: posterior edges of segments bear minute denticuli. Light olive, becoming lighter distally.

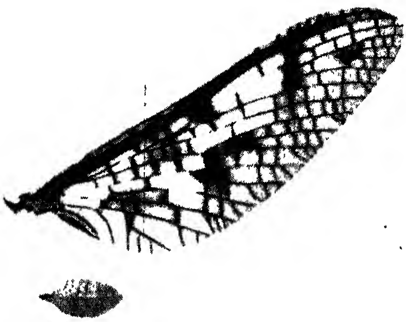
Gills (Text-Fig. 10)—There are pairs of simple double gills on the first seven abdominal segments. The first six consist of a pair of acuminate, ovate, yellow lamellae with black pinnate venation. Their edges are entire and they are incessantly vibrated at a moderate speed. The seventh pair consist of a bifid lash, each part of which contains a thick central trachea, unbranched and bordered on each side with a narrow strip of lamella. This pair of gills is only slightly vibrated and is probably, almost, if not quite, aborted.

Distribution—Slow and moderately-flowing waters of the following districts of New Zealand: Auckland, Hawkes Bay, Wellington, Nelson and Canterbury.

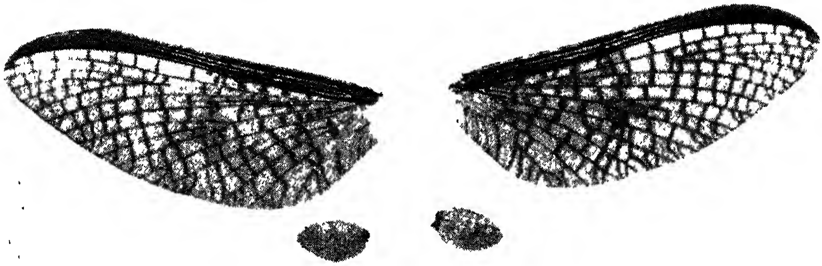
Atalophlebia dentata (Eaton).

The winged stages of this insect were first described by Eaton (17), from dried specimens, under the name *Leptophlebia dentata*, later (4) under its present name and again (5), slightly amended, after receiving further specimens from this country.

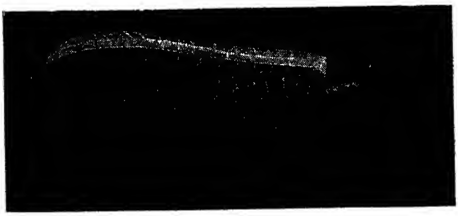
Hudson (1) gives notes of all stages. It is easily confused with both *A. cruentata* and *A. versicolor;* with the former in the imaginal



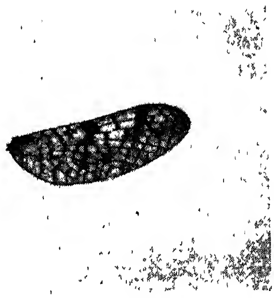
Atalophlebia versicolor.
FIG. 1.—♀ Wings of Sub-imago × 4.



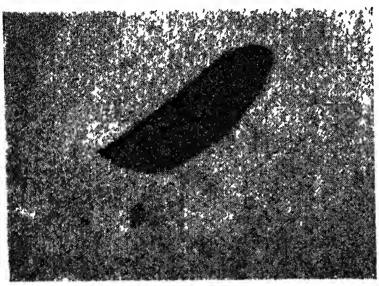
Atalophlebia dentata.
FIG. 2.—Sub-imago × 4.



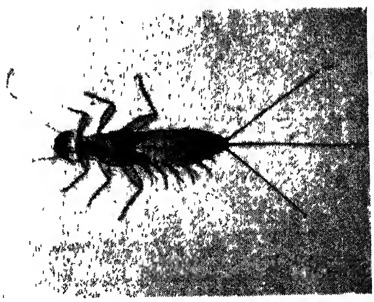
Atalophlebia cruentata.
FIG. 3.—Wings of ♂ Imago. × 4.



Atalophlebia nodularis.
FIG. 4.—Sub-imago. × 3.

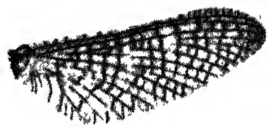


Atalophlebia nodularis.
FIG. 5.—♀ Imago. × 3.



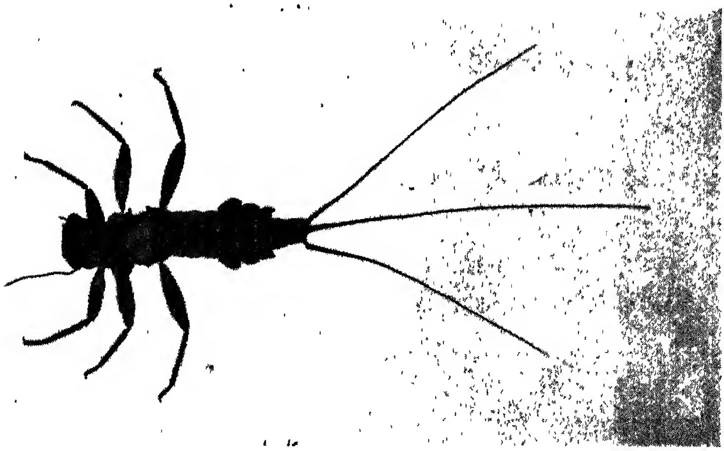
Atalophlebia nodularis.
FIG. 6.—Nymph. × 3.

Deleatidium lillii.
FIG. 7.—Sub-imaginal forewing × 3½.

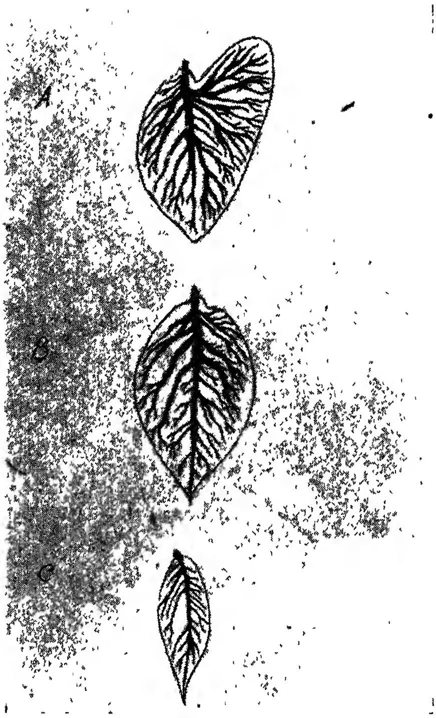


Deleatidium autumnale.
FIG. 8.—Sub-imaginal forewing × 2.

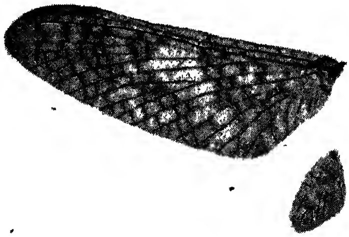
Deleatidium vernale.
FIG. 9.—Sub-imaginal forewing × 3½



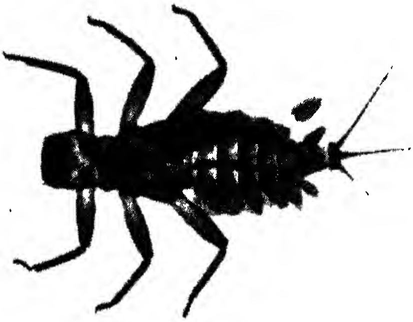
Deleatidium lillii.
FIG. 10.—Final nymphal exuvia × 4.
With wing pads and some gills removed.



Nymph of *Deleatidium lilli*.
FIG. 11.—Gill of First, fourth and seventh pairs, Ca. × 16.

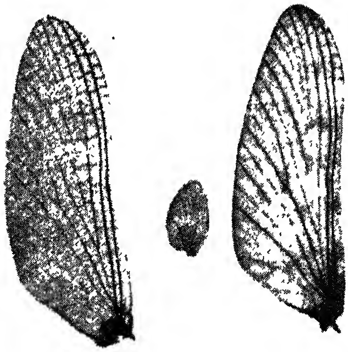


Deleatidium myzobranchia.
FIG. 12.—♀ Sub-imago Ca. × 4.

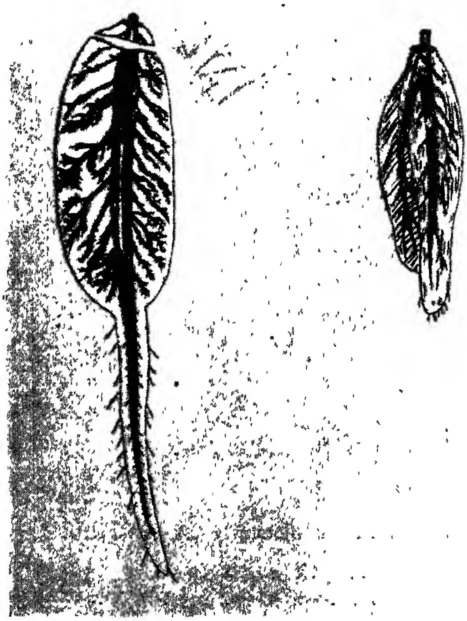


Deleatidium myzobranchia.
FIG. 13.—Nymph. × 3.

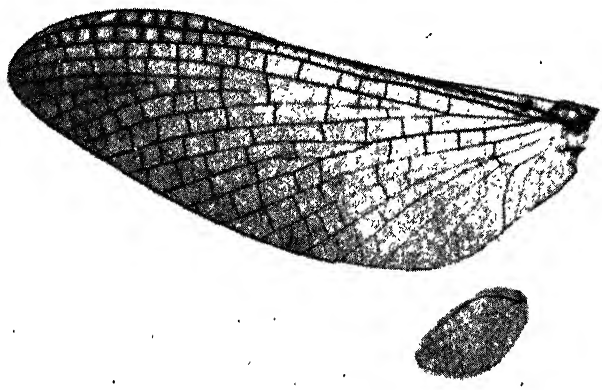
Deleatidium cerinum.
FIG. 14.—♀ Sub-imago. × 4.



Deleatidium (*Atalophlebioides*) *sepia*.
FIG 15.—Right fore- and hindwing of Sub-imago and right forewing of Imago. × 4.



Nymph of *Deleatidium* (*Atalophlebioides*) *sepia*.
FIG. 16.—Outer lamella of gill of fourth pair and gill of seventh pair, much enlarged.



Deleatidium lillii.
FIG. 17.— Imago. × 9.

Nymph of *Deleatidium (Atalophlebioides) cromwelli.*
FIG. 18.—Canine region of mandible, greatly enlarged.

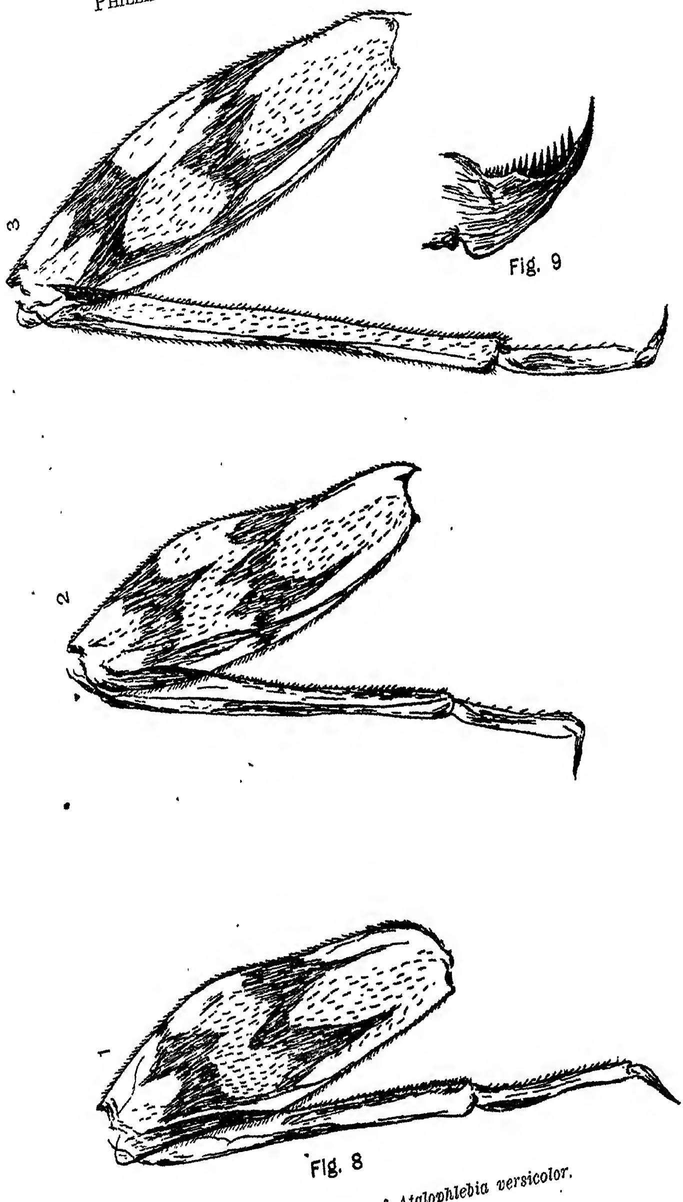


Fig. 9

Fig. 8

Nymph of *Atalophlebia versicolor*.
FIG. 8.—Legs. × 25.
FIG. 9.—Tarsal claw, much enlarged.

and sub-imaginal stages and with the latter in the nymphal and imaginal stages.

The vivid red colour of the costal region in the imago, mentioned by Hudson (1) and by Eaton (4), but subsequently modified by the latter (5) to dark amber yellow (raw sienna), must not be taken as a point to distinguish it from *A. versicolor,* for the colour of this region varies greatly. The colour of the legs and of the abdomen is a much safer guide.

Nymph—As *A. versicolor,* described above, but it is shorter and stouter, and there are also the following differences:

	A. versicolor	*A. dentata*
Femora	Ground colour yellow with two dark sinuous bands.	Ground colour grey with patches apically and medianly.
Between eyes	A yellow spot.	None.
On dorsum	Yellow median line longitudinally.	None.
do.	Yellow triangle posteriorly.	None.

IMAGO.

Length—8 to 9 mm., excluding setae.

Head—Fawn, with brown markings. Ocelli yellow amber, rimmed in brown.

Eyes of female, olive; of male, upper lobes orange brown, lower lobes olive.

Thorax—Light brown with dark brown markings.

Abdomen—Light bistre-brown, modified in segments eight to ten with burnt umber, the first eight segments black-rimmed posteriorly. Ventral lobe of female emarginate. Claspers lutescent, greyish distally; three-segmented; dilated at base. Penes reddish, 'lobes contiguous with each other throughout, elongate triangular and thin with their outer edges thickened.' (Eaton).

Caudal setae—Light fawn to sepia grey with black joinings; median setae—male, 18 mm.; female, 15.5 mm.; outer ones—male, 16 mm.; female, 14 mm.

Legs—Femora and tibiae barley-sugar orange, darkened distally; fore-femora slightly darker. Tarsi flavescent, tipped with grey at joinings.

Wings—Length of forewing—male, 12 mm.; female, 13 mm.

"Wings vitreous, the disc very faintly tinted with yellowish: marginal and sub-marginal areas of the forewings coloured with dark amber yellow (raw sienna), the sub-marginal area wholly, the marginal area only in part, viz., from the base to the middle and in the pterostigmatic space completely, but only in about one-third its breadth along the sub-costa in the intervening space: the cross-veinlets in the marginal area before the pterostigmatic space and those in the sub-marginal area are bordered with dark bistre-brown and give rise to a blotch or cloud at the bulla. Neuration mostly pitch-black, but the nervures near the wing-roots, and the stouter parts of the costa, subcosta and radius are pitch-brown. Cross-veins in marginal area about five before and fifteen beyond the bulla, all straight." (Eaton).

Egg—An irregularly-shaped oval, with bosses, pits and sculptured chorion. It may be distinguished from the egg of *A. cruentata,* by its far more irregular outline and by its bosses, which are placed singly and not in groups of two or three.

SUB-IMAGO.

Wings (Pl. 62, Fig. 2)—Surface cloudy white, but occasionally tinted with dull brown or orange: costal region dark amber yellow, darker midway and in pterostigmatic region. Veins blackish, cross-veins irregularly-bordered with grey. Often, a thin grey band may be noticed, running across the wing-surface medianly at right angles to the costa, formed by the greyish bordering of cross-veins and a lighter and more irregular area three-quarters of the way towards the wing-tip in the anterior portion. Hindwing coloured as forewing. Sc. orange, other veins black.

The winged stages of this species appear throughout the summer and even up till the month of April.

Distribution—Auckland, Hawkes Bay, Wellington, and Nelson provincial districts.

Atalophlebia cruentata Hudson.

IMAGO.

Length (excluding setae)—12 mm.

Head—Black median line down frons: elsewhere light orange with black markings. *Eyes*—female, dull yellowish-green; male, lower lobes as in female, upper lobes bright orange. *Ocelli*—orange red.

Thorax—Light orange with black markings.

Abdomen—Dorsum, dull red: dark line at posterior edges of segments. There is a dark median line throughout the length, except on the tenth segment: this segment is lighter than the rest and more orange in tint. Venter—dull red, becoming lighter posteriorly: posterior edge of segments 1 to 9 dark-rimmed.

Penes very light orange (Text-Fig. 11). Claspers as penes, but becoming almost colourless distally and tinged with light grey: dilated at base: three-jointed.

Caudal setae flavescent with black joinings: median seta, 18 mm.; outer setae, 16 mm.

Legs—*Anterior pair*—Femora orange with brown transverse bar two-thirds of the way towards distal end. Tibiae orange, tipped with black distally. Tarsi flavescent (almost colourless), tipped with black at distal end of each segment.

Other pairs—Femora orange (those of third pair the longest).

Tibiae light orange, becoming flavescent distally and slightly tipped with black apically. Tarsi flavescent, very slightly tipped with black at distal end of each segment: four-jointed.

Egg (illustrated in Part 1 of this paper, Plate 52, Fig. 5)—Oval, covered at regular intervals with numerous bosses in groups of two or three, and many very minute pits.

Wings (Pl. 62, Fig. 3)—Forewings hyaline, except the costal and sub-costal areas which are orange. Cross-veins pitch black. Prominent bulla on Sc. and a smaller one on R2a. There are six simple marginal cross-veins interior to the humeral; they broaden as they approach the costa.

Hindwings hyaline, except the costal region which is orange. Veins black. Wing expanse, 28 to 30 mm.

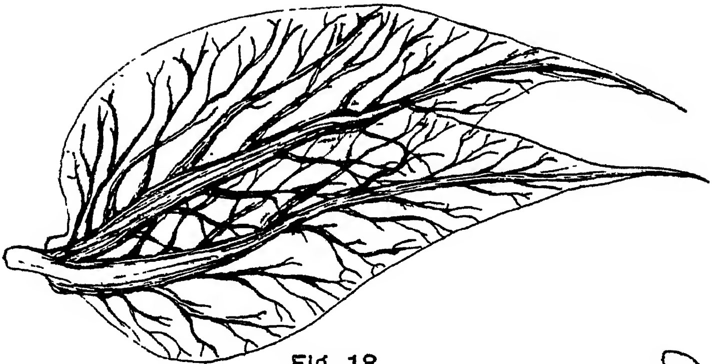


Fig. 18

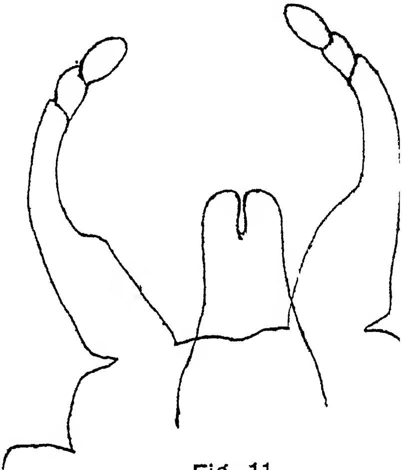


Fig. 11

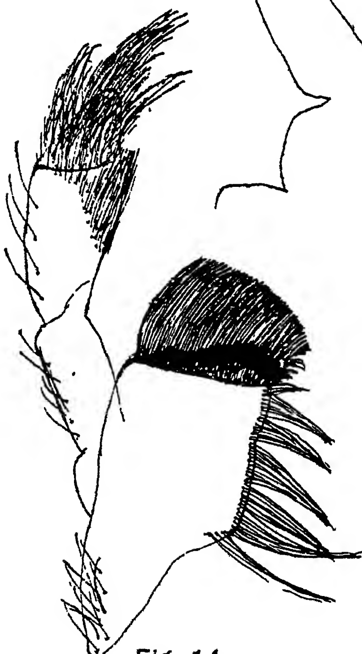


Fig. 14

Atalophlebia cruentata.

FIG. 11.—Penes. × 24.
FIG. 14.—Maxilla. × 60.
FIG. 18.—Gill. × 24.

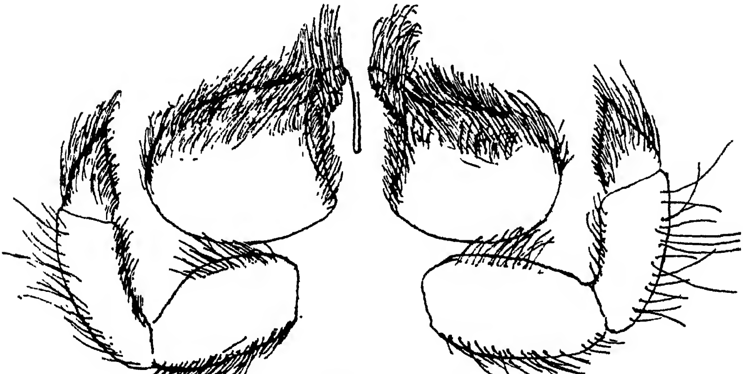


Fig. 15

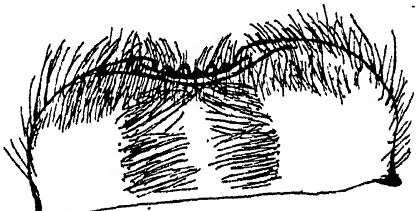


Fig. 12

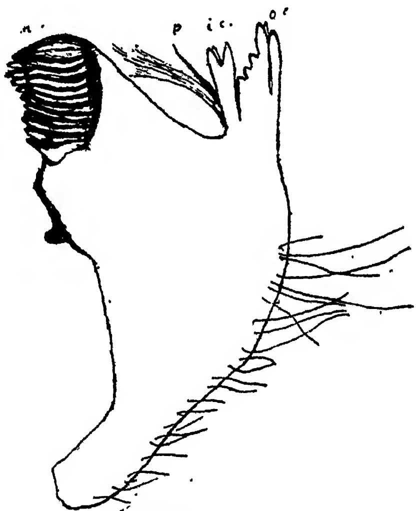


Fig. 13

Nymph of *Atalophlebia cruentata.*

FIG. 12.—Labrum. × 60.
FIG. 13.—Mandible. × 60.
FIG. 15.—Labium. × 60.

In the shape and venation of the wings this species is similar to *A. dentata,* but the imago of *A. cruentata* can easily be distinguished from the latter by the dark bar on the anterior femora and the orange costal region of the hindwings.

Wings of Sub-imago—Wing-surface of forewings light pearly brown, except costal region which is orange red, but brick red at extreme base. At the wing base, an orange bar runs from costa to cubitus. Cross-veins black, bordered irregularly with grey. Other veins nearly colourless.

In the hindwing, the proximal half of the marginal area is orange and the remainder of the surface is pale pinkish-pearl. The main veins are colourless, the cross-veins grey, irregularly bordered.

Nymph.

This nymph lives among sand, shingle, or under stones in the beds of streams: it prefers the shallow, less rapid parts and shuns the light. It is rather difficult to catch, as immediately it is uncovered it edges away very quickly into the nearest cranny, where it hides itself with considerable skill. If it were not for its bright colour it would be extremely difficult to secure.

Description.

Length (excluding setae)—Ca., 12 mm.

Colour—Bright orange red.

Head—Light red with black markings: small.

Eyes—Male, upper lobes dark orange; lower lobes dark olive. Female, dark olive.

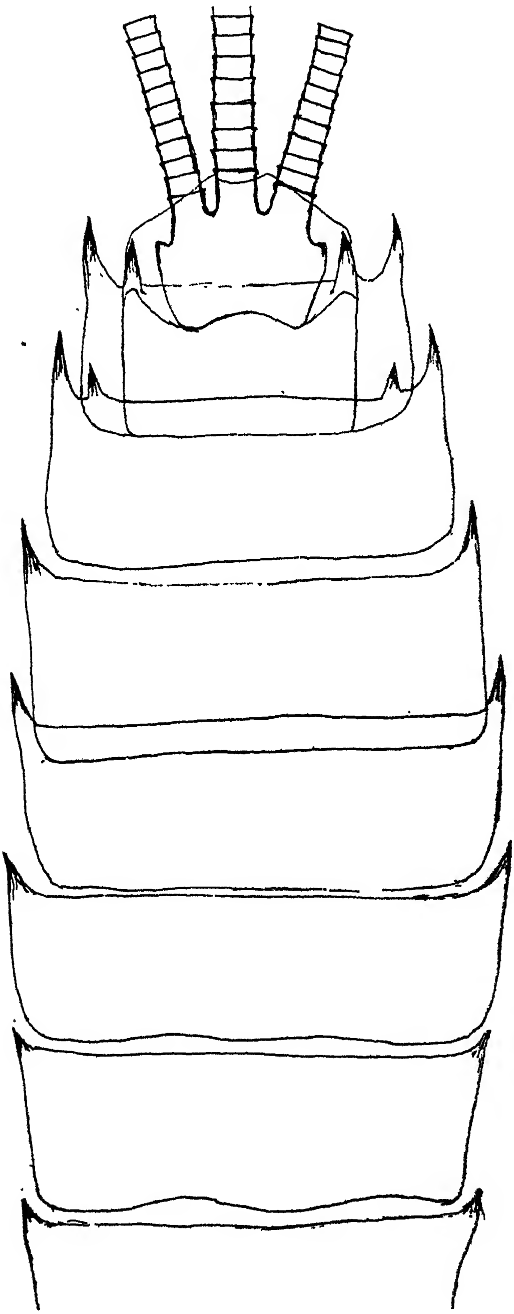
Ocelli—Black.

Antennae—Orange, filiform; about twice as long as the head.

Labrum (Text-Fig. 12)—Two and a half times as broad as it is long. The anterior edge has an inward median curve with five well-marked teeth, of which the central one is the smallest. The posterior border is almost straight, but its lateral angles are produced slightly backwards and outwards.

Mandibles (Text-Fig. 13)—Outer canine (o.c.) with three teeth, inner canine (i.c.) with three teeth. Edges of the outer canine are crenately serrated. Prostheca (p.) very thin, deeply serrated at edge, with prominent brush of long brown hairs interior to it and directed inwards. Molar surface (m.) with about eleven parallel transverse ridges, armed with bristles. A prominent chitinised knob projects from the angle proximal to the molar surface.

Maxilla (Text-Fig. 14)—Palp three-segmented; median segment broadest, basal segment about two-thirds as broad and as long, apical segment the smallest and triangular in shape, covered all over with long spines: the two proximal segments bear spines on the outer edges only. The galea-lacinia bears the usual terminal brush of long brown hair and a row of pectinate rakes distally and also the long fringe of hair on the inner margin, but the shape of the maxilla is unusual, as it becomes somewhat narrower towards the base instead of broader, as is generally the case.



Nymph of *Atalophlebia cruentata.*

FIG. 16.—Posterior portion of abdomen (exuvia) × 24 dorsal view.

Hypopharynx—As in *A. versicolor,* but the anterior edges of the superlinguae curve more deeply inwards towards the middle of the hypopharynx.

Labium (Text-Fig. 15)—Palp three-segmented; basal segment longest and broadest, the two distal ones have coalesced, but the suture is still visible; their inner edges form a straight line, their outer ones a convex bend, so that the palp is pointed. The distal segment is covered with long spines as are the edges of the two basal segments. Glossae very narrow, curved and with long hairs distally and bearing a few short spines on the surfaces. Paraglossae about four times as wide as the glossae, covered with hairs and spines in the distal portions and on those parts of the surfaces which are near the glossae: outer margins curved convexly, inner and anterior margins almost straight.

Thorax—Small and narrow. Light orange with black markings dorsally. Wing-pads orange, stippled with black and black-edged, but appearing deep black in mature specimens.

Abdomen (Text-Fig. 16)—The posterior-lateral angles of segments are toothed backwards, very pronouncedly so in the posterior half, but not in the tenth segment: the segments are broadest in the mid-portion of the abdomen.

Dorsum—Bright orange, becoming vivid and more reddish posteriorly. Anteriorly there are dark median markings, also near the gill insertions and on the posterior rims of segments, but these become less noticeable posteriorly.

Venter—Pale orange, becoming darker posteriorly.

Caudal setae — Orange, becoming lighter posteriorly: black-rimmed at joints. Outer ones, 8 mm.; median seta, 9 mm.

Legs (Text-Fig. 17)—Colour orange. Order of length 3, 2, 1. The femora are dilated, those of the anterior pair have a median darker-shaded area (not shown in drawing).

The legs are spinose as in *A. versicolor* and there are fringes of hair along the edges of the tibiae and tarsi and also on those of the anterior femora. Along the ventral edge of the fore-tibiae, the spines are curiously feathered (cf. *Ichthybotus hudsoni*).

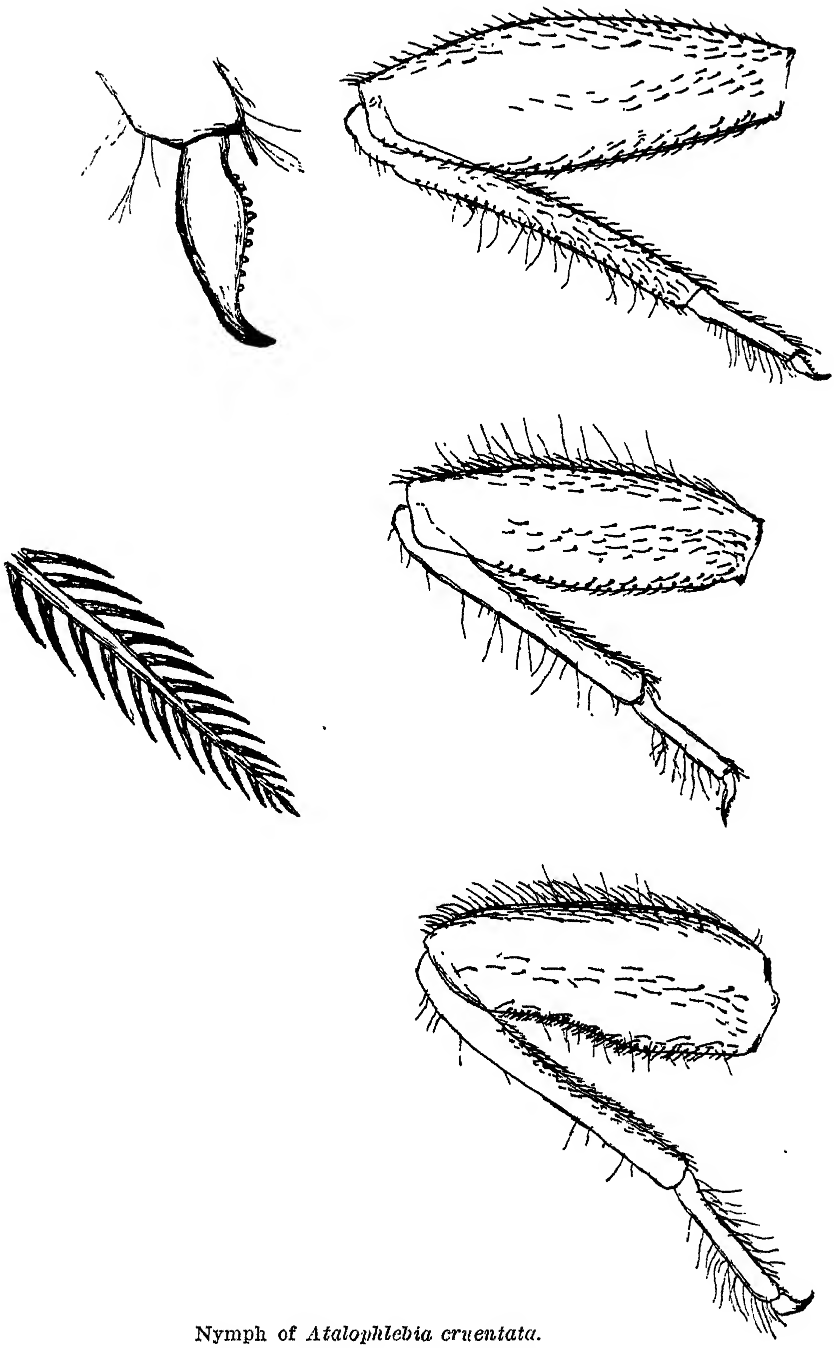
Gills (Text-Fig. 18)—Pairs of double gills, which are moderately vibrated, are borne laterally on the first seven abdominal segments. The gills of the first six pairs are ovate-acuminate, those of the seventh pair are smaller, narrower and are only slightly vibrated. The gill surfaces are pale orange: the venation is black, pinnate with strong central tracheae.

Distribution—Auckland, Hawkes Bay, Wellington, Nelson and Canterbury districts.

Atalophlebia nodularis (Eaton).

This species has already been described in part by Eaton (17) and (4), and further by Lillie (3).

Hudson (1) states, 'I have been unable to identify this species with certainty,' and it was only in the third year of my investigations that I was able to place this insect definitely.



Nymph of *Atalophlebia cruentata.*

FIG. 17.—Legs. × 24, tarsal claw and feathered hair, greatly enlarged.

This was due partly to the fact that it is by no means common in the Wellington district, and partly because the previous descriptions are incomplete and do not seem to tally, in certain particulars, either with each other or with the actual fly.

From time to time, I secured at Khandallah and elsewhere an occasional specimen, which seemed to resemble *A. nodularis,* as described, with certain differences, and towards the end of January, 1930, whilst examining the fauna of the Gowan River at its exit from Lake Rotoroa, Nelson district, I found this species in swarms, and concluded, as the points of resemblance far outweighed the few differences and as there was no other fly at all like it, that it must be the species described by Eaton and Lillie as *A. nodularis.*

As Lillie (3) has figured various parts of the nymph and imago, I am illustrating the following points only: sub-imaginal forewing (Pl. 62, Fig. 4) to show markings, imaginal forewing (Pl. 62, Fig. 5) —Lillie's figure shows the venation, but not the very characteristic pattern of the marginal and sub-marginal areas—and the nymph (Pl. 62, Fig. 6), as it would be rather difficult to identify the insect from Lillie's Fig. 4d (3).

Imago.

Length—8.5 mm., excluding setae.

Head—Light brown with dark brown markings. Ocelli grey. Eyes of female and lower lobes of those of male dark brown, upper lobes orange red.

Thorax—Windsor and Newton's ' Roman sepia ' brown.

Abdomen—Same colour as thorax, with light rings at posterior edges of the first eight segments: ventral valve emarginate: venter fawn. Penes and claspers brown; the latter three-segmented, with long proximal segment dilated at base and distal segments short and sub-equal.

Caudal setae—Very light grey with broad black joinings, which become broader distally: uniformly covered with soft hairs: outer setae—male, 16 mm.; female, 13 mm.; median seta—male, 14 mm.; female, 11.5 mm.

Legs—Femora light raw umber with a dark median band, in the first pair a dark distal band. Tibiae light brown ochre, with a dark distal band in the first pair only, faintly and narrowly shown in the other pairs. Tarsi lighter than tibiae and with greyish tinge: joints narrowly edged with black: four-segmented.

Wings (Pl. 62, Fig. 5)—Length of forewing—male, 9.5 mm.; female, 10 mm. Surface vitreous with dark brown or black venation, except costa, sub-costa and R1, which are brown: cross-veins of costal and sub-costal areas heavily and irregularly-bordered with dark brown: cross-veins in area posterior to R1 edged narrowly only and in remaining areas not edged at all. Half way along the wing, the edgings in the three anterior areas spread into the wing surface, forming a small blurred area.

Anterior of wing-base light brown.

Egg—Very irregularly-shaped with dark circumscribing line indicating mucilaginous matrix: it has anchor ropes attached to each

of the polar regions and these ropes are almost invisible and require very careful focussing of the microscope to spot.

Surface of chorion obscured by mucilaginous coat; there are, however, indications of minute pits, showing through the coat.

SUB-IMAGO (Pl. 62, Fig. 4).

Wings—Surface mainly grey with irregular pearly spaces. Cross-veins in the costal and sub-costal areas narrowly edged with heavy black, giving them a thick appearance. In the other areas, they are more broadly and irregularly-edged with light grey: these grey areas run together in places, and in others—notably in the anterior portions of the wing—they are more nearly confined to the immediate vicinity of the cross-veins, thus forming the irregular pearly spaces.

NYMPH (Pl. 62, Fig. 6).

This lives in slow and moderately-flowing water on the stream bed among stones and débris. It can be recognised by the shortness of its caudal setae in comparison with its body, by the orange colour of the posterior of the dorsum, by the stillness of its thin, Y-shaped gills and by its being in some way suggestive of a miniature *Atalophlebia cruentata.*

Length—8 mm., excluding setae.

Head—Square; rounded and haired anteriorly, where it has a reddish tinge. Eyes of female black or dark brown; those of male resembling these of female in lower portion, olive brown in upper portion. Mouthparts as in other *Atalophlebia* spp.

Thorax—Olive brown. Wing-pads small, olive brown, covering the first two abdominal segments.

Abdomen—Olive brown or reddish orange, tinted grey; anterior six segments with thin, black rim posteriorly, posterior four segments tinted orange: latero-posterior angles of sixth to ninth segments toothed backwards and yellowish in tint. There is a yellow mark on each side of the abdomen, placed latero-anteriorly on each segment.

Caudal setae olive brown or reddish-brown; joinings darker and whorled with short hairs and a row of minute spines pointing backwards: median one, 6 mm.; outer ones, 4.5 mm.

Legs—Almost colourless: third pair longest, first pair shortest. Femora short and stout, with grey marks medianly and at ends and small spines distributed over surfaces. Tibiae and tarsi with light brown or pinkish tinge: rows of spines on dorsal and ventral edges and a row of hairs on the dorsal edges.

Gills—Pairs of thin, double gills appear latero-posteriorly on the first seven abdominal segments. The gills are seldom vibrated and consist each of a pair of lanceolate-acuminate lamellae, joined at the base, each lamella containing a thick unbranched central trachea. The gills of the seventh pair are the smallest, those of the first and sixth pairs being somewhat smaller than those of the remaining ones.

Distribution—Moderately swift streams in the Wellington and Nelson provincial districts.—*Hutton.* Christchurch and Dunedin.

Atalophlebia ? n. sp.

Whilst I was on a brief visit to the North Auckland district, the nymph of a new species of *Atalophlebia* was found in a small woodland stream on the property of Mr. F. Heaton, of Tanekaha, a few miles west of Hikurangi.

In this stream, which was a moderately rapid one, were a number of Ephemerids, including *Atalophlebia versicolor, A. cruentata* and a species of *Ameletus,* which may have been a new one, but unfortunately, at this time (beginning of March), all the individuals of this species were too small to note slight differentiations from type with any certainty.

The new Atalophlebid was present in considerable numbers; it was comparatively large, conspicuously marked and therefore easily distinguished.

Owing to the fleeting nature of the visit, it was impossible to secure the winged stages or even to keep the nymphs alive until they transformed. Accordingly, they were placed in preserving fluid and taken back to Wellington.

This species cannot be given a name until the winged stages have been found, but for convenience, I have given it the provisional name of *A. borealis* in my notebook.

Description (from preserved specimen).

Length (excluding setae)—Ca., 12 mm.

Head—Large; sub-quadrangular, with slightly convex margins. Ground colour yellow, covered all over with fine sepia stipling, except on three small areas, one exterior to each ocellus. *Eyes* large, dark brown. *Mouthparts* of the typical Atalophlebid description. The median bay of the anterior edge of the labrum bears five prominent teeth.

Thorax—Yellow with sepia stipling: wing-pads cover the first two abdominal segments.

Abdomen—Very broad, narrowing considerably posteriorly: latero-posterior angles of segments six to nine project backwards as sharp teeth: the ninth and tenth segments are telescoped, the former, in particular, having a much narrower area visible than is usual in this genus. The ground colour is yellowish; heavy, symmetrical, dark markings, on each side of the median line, are found dorsally on the first nine segments: ventrally, the dark markings are placed in a median area on each of these segments and are suggestive of the same markings in *Oniscigaster.*

Caudal setae (broken)—Apparently ca. 12 mm.: yellow: whorls of very short, fine hairs occur at the joinings.

Legs—Colour dingy yellowish-brown (but markings possibly washed out by preservative).

The femora and tibiae of the middle pair of legs are somewhat longer than those of the anterior pair, but the tarsi are slightly shorter. The femora and tibiae of the posterior pair are longer than those of the other two pairs, the tarsi being about the same length as in the anterior pair.

There are spines on the surfaces and on the dorsal and ventral edges of all the femora, on the ventral edges of the tibiae (fewer on those of the middle pair of legs), on the dorsal edge of the posterior tibiae only and on the ventral edges of the posterior and anterior tarsi. There are fringes of a few weak hairs on the dorsal edges of the tibiae of the second and third pairs of legs.

The tarsal claws are toothed underneath.

Gills—There is a pair of gills on each of the first seven abdominal segments. The gills become smaller posteriorly. Each gill consists of a pair of ovate-acuminate lamellae. The tracheal venation is pinnate with a stout central trachea. The gills of the last pair are very small and the inner lamella is minute: both have a central trachea but no pinnate branches.

Genus DELELATIDIUM Eaton (1899).

Adult—" Distinguished as a genus from *Leptoplebia* by the male imago having genitalia conformable in pattern to those of an *Atalophlebia*. . . ." (Eaton).

Nymph—Nymph of the crawling type. Body markedly flattened dorso-ventrally. Nymph generally found under stones. Head square. Eyes lateral. Antennae long and filiform. Maxillary and labial palps three-segmented. Labrum at least three times as broad as it is long and notched medio-anteriorly. Maxilla with broad terminal brush of long brown hairs and small pectinate rakes. Wing-pads large. Legs long, spinose: femora very much dilated: claws toothed underneath. Latero-posterior angles of abdomen mostly toothed backwards, pronouncedly so in the posterior half. Caudal setae as long as or longer than the body; median seta longest. Pairs of gills borne laterally on the first seven abdominal segments: the gills are single: those of the first pair are kidney-shaped in outline, those of the other pairs ovate-acuminate or sub-rotund.

The only *Deleatidium*, described previously, was *D. lillii* (1), (3), (4), (5), (17), and (18). Of the six species of this genus, described below, four are extraordinarily alike. The remaining two are somewhat different in appearance. The first of these, *D. myzobranchia* n. sp. may possibly have to be placed in a new genus, at a later date. The second, *D. cerinum* n. sp., is very minute and has a subimago with wings of a waxen or dead-skin colour, which makes it easy to recognise as it emerges from the nymphal exuvia at dusk, on the rivers.

There are slight differences in the New Zealand *Deleatidium* nymphs and the characters ascribed to that genus (based on Neotropical species) by Needham and Murphy (9).

New Zealand species of this genus are extensively eaten by trout and by other fish, as well as by predatory insects, such as the nymphs of stoneflies, and they have other enemies, for on examining the stomach of a *Deleatidium* nymph, it was found to contain a large number of Nematodes. These parasitic worms are also found in the winged stages, so they obviously occur in that part of the alimentary tract, which is not cast off, when the insect moults.

There are at least three species of *Deleatidium*, which have almost identical nymphal and imaginal forms, but entirely distinctive sub-

imaginal wings. One of these only, *D. lillii,* has been described. (1) and (3).

The sub-imaginal wings of *D. lillii* (Pl. 63, Fig. 7) are of a uniform smoky-grey, those of the other two species (Pl. 63, Figs. 8 and 9) and (3) have a pearly ground colour and are irregularly-marked with dark grey, the pattern of the markings differing in the two species.

These latter two species have been secured at different seasons of the year, the one in spring and early summer, the other during the summer and autumn. I am therefore naming them *D. vernale* and *D. autumnale* respectively.

Nymphs of *D. lillii,* on the other hand, have been seen to metamorphose almost all the year round, even in midwinter.

It is of interest to note, however, that two specimens (1 male, 1 female) which were secured as nymphs on July 4th, 1929, changing the same day into sub-imagines, failed to reach the imaginal stage. They attempted to do so in the laboratory about thirty-six hours later, but apparently had not the necessary energy and died, partly metamorphosed. Whether this is usually, or perhaps often, the case in winter, is not known.

To differentiate between the nymphs of *D. lillii* and *D. vernale,* the gills may be examined, as explained in a later paragraph. However, as individuals of the same species also show slight variations, this is by no means a satisfactory test.

In such specimens as have been examined, there would appear to be slight differences in the dorsal markings of the thorax and abdomen, but as it has so far only been possible to compare the final nymphal exuviae, and only a very limited number of these, and as, moreover, the differences in the appearance of instars of the same species are far more marked than the differences between the species, more data will be required before a definite statement of specific differences, so far as nymphs are concerned, can be made.

The markedness of the differences in the appearance of a given species of *Deleatidium* in various instars is most extraordinary, and is such that only an experienced observer would recognise that he was dealing with members of the same species. Nevertheless, these changes in appearance—except for the alteration in size and shape of wing-pads—are due entirely to the different intensity of pigmentation in the various markings.

Differences in the character of the riverbed also affect the colour scheme of this nymph.

Individuals of species of *Deleatidium* are perhaps more abundant than those of any other genus of mayfly. They are feeble swimmers, clinging to the under-surfaces of stones and boulders in slow and also in rapid waters. They are also found buried in the sand and shingle of the river bed, and—especially in winter-time—among submerged moss, and waterside vegetation of many kinds.

Keys to N.Z. Species of Deleatidium.

Imagines.

A. Costal vein faint and inconspicuous except towards wing-tip .... *Deleatidium cerinum* n. sp. Page 382

B. Costal vein strongly-marked:
  1. Costal and sub-costal region of forewing tinted with rose-madder pink, distally or entirely .. .. *Deleatidium myzobranchia* n. sp. Page 373
  2. Not as above:
    (a) Length of body (excluding setae), 7 mm. or less.
      (i) Abdominal segments dark-rimmed posteriorly .. .. *Deleatidium fumosum* n. sp. Page 372
      (ii) Not as above . .. . *D. (Atalophlebioides) cromwelli* n. sp. Page 385
    (b) Length of body (excluding setae), more than 7 mm.
      (i) With heavy dark band at 'knee' .. . *D. (Atalophlebioides) sepia* n. sp. Page 383
      (ii) Not as above:
        Abdomen reddish-brown dorsally .... *D. lillii* (Walker) Page 368
        Abdomen dark fawn dorsally, with a light median area on each segment... . *D. vernale* n. sp. Page 360
        Abdomen light brown dorsally, shaded in the median and lateral portions with dark grey markings . . .. . *D. autumnale* n. sp. Page 371

Sub-Imagines.

A. *Wings waxen-white* . ... *Deleatidium cerinum* n. sp. Page 382

B. *Wings grey—*
  (i) Wings pearly-grey .... *D. (Atalophlebioides) cromwelli* n. sp. Page 385
  (ii) Wings or area along each side of main veins deep sepia-grey .... *D. (Atalophlebioides) sepia* n. sp. Page 383
  (iii) Wings smoky-grey—
    (a) Wing Expanse ca., 20 mm. . ... *D. lillii* (Walker) Page 368
    (b) Wing Expanse ca., 15 mm. ... . *D. fumosum* n. sp. Page 372

C. *Wings variegated—*
  (i) Distal region of costal and sub-costal areas rose-madder pink .... *D. myzobranchia* n. sp. Page 373
  (ii) Not as above—
    (a) Wing pattern as in Fig. 3K. ♂ wings larger than those of ♀ .... *D. vernale* n. sp. Page 360
    (b) Wing pattern as in Fig. 2K. ♂ wings *not* larger than those of ♀ ... . . *D. autumnale* n. sp. Page 371

Nymphs.

No key to the nymphs of this genus is given for the following reasons:—

D. lillii, D. vernale and *D. autumnale* cannot be distinguished from each other with any certainty in this stage until they have received further and more intensive study.

With regard to the nymphs of *D. fumosum* and *D. cerinum*, so far it was only from the last nymphal exuviae that I have been able to distinguish between them on the one hand and *D. lillii, D. vernale* and *D. autumnale* on the other.

Fully-grown specimens of the first-named nymphs are only distinguishable from the younger stages of the other species, because they have fully-developed wing-pads, whereas the other species of the genus have not.

D. (*Atalophlebioides*) *sepia* and *D.* (*Atalophlebioides*) *cromwelli* have double gills and are therefore included in the nymphal key to *Atalophlebia* species.

D. myzobranchia has the gills rounded apically and not acute.

Deleatidium vernale n. sp.

Imago.

Length (excluding setae)—Male, 8 to 9 mm.; female, 6.5 to 8 mm.

Wings—Expanse, 19 mm.

Surface hyaline except in the costal and sub-costal areas, which are very faintly tinted with light brown and the wing-base, which is more pronouncedly coloured.

Veins dark brown, becoming lighter posteriorly till they are almost colourless in the anal region. Sc and R1 light brown. Cross-veins in proximal part of costal area colourless, in the distal part deep brown.

Bullae are present on Sc, R2 and R4 + 5.

Hindwing—Surface colourless as are the veins, except at the wing-base and in the distal anterior quarter of the wing, where they are brownish.

Head—Olive brown.

Eyes — Male: upper lobes, reddish-brown; lower lobes, olive brown; female: olive brown.

Ocelli—Greenish.

Thorax—Olive brown.

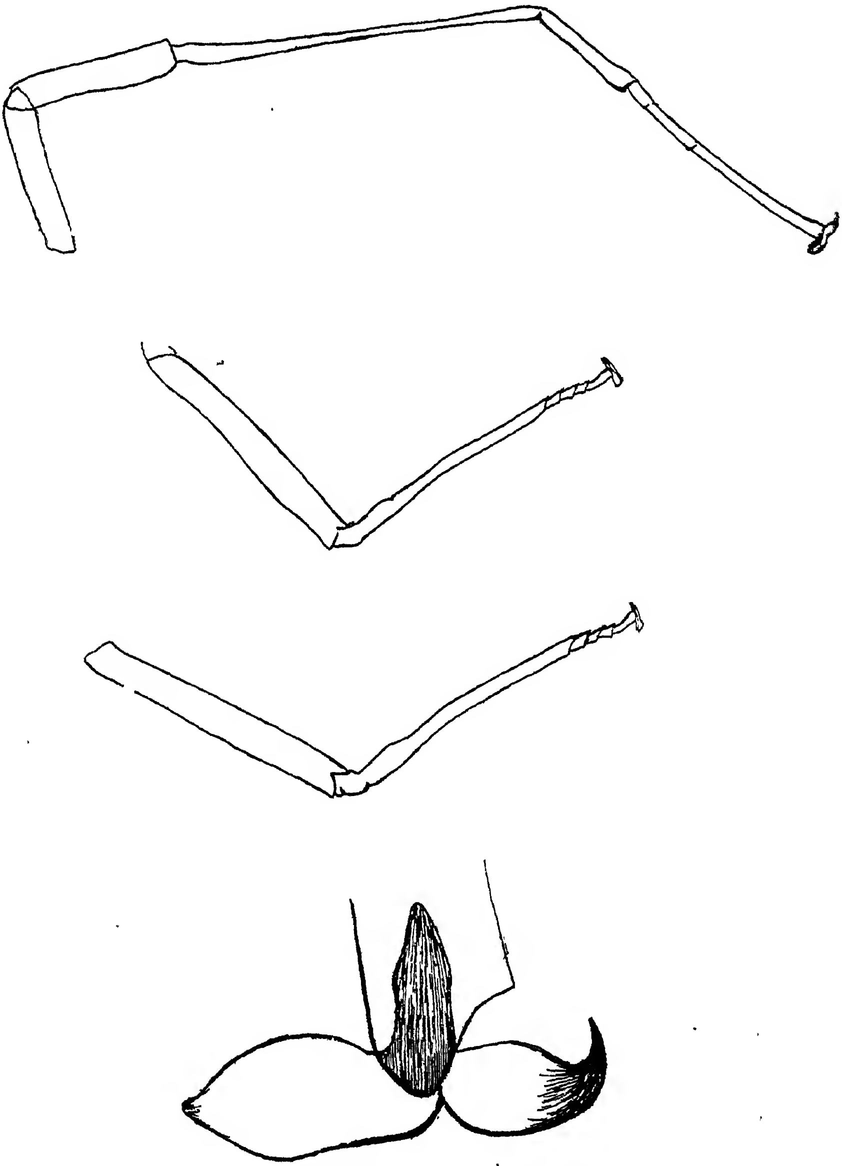
Abdomen—dorsum—Ground colour dark fawn; an irregular median area of each segment is of a lighter shade and there is a light median line bisecting the first eight abdominal segments and the posterior edges of these segments have whitish bands: the ninth segment has a pinkish tinge and its posterior-lateral angles project backwards as sharp teeth.

Venter—Ground colour dark fawn: there is an irregular dark median line on the first eight segments, which have white rings at the posterior edges.

Claspers light brown, becoming much lighter distally: three-jointed: dilated at base. Penes bright orange brown.

Caudal setae—Light brown, darker at joints. Male: median one, 15 mm.; outer ones, 13 mm.; female: median one, 11.5 mm.; outer ones, 10 mm.

Legs (Text-Fig. 19)—Femora light brown. Tibiae flavescent. Tarsi flavescent, tinged with grey; four-jointed. Tibiae and tarsi sub-equal in length. Hind tibiae about four times as long as tarsi.



Deleatidium Vernale.

FIG. 19.—Legs of ♂ Imago × 22, and tarsal claw, much enlarged.

There are two unlike claws at the end of each tarsus, the one being narrow and hooked at tip, the other broad and blunt. Male foreleg, as usual, very long, as, though the femur and tibiae are shorter than those of the hinder legs, the tibia is enormously elongated.

In this species, the male is larger than the female, which is unusual among Ephemeroptera, and is not the case in *D. lillii;* the latter species also shows slight differences in colouration and markings from *D. vernale.*

SUB-IMAGO.

Length (excluding setae)—Male, 8 mm.; female, 7.5 mm.

Wings (Pl. 63, Fig. 9)—Surface pearly. Wing-base lightly tinged with reddish-brown, as are very faintly the costal and subcostal areas.

Veins Sc and R1 fawn; the rest black.

Bullae present on Sc, R2, and R4 + 5.

Cross-veins irregularly bordered with grey except in the anal area.

Head—Fawn, with yellow markings dorsally.

Antennae—Basal joint very thick; orange brown; the rest filiform; grey.

Eyes—Male: upper lobe orange brown, lower lobes olive: female: olive.

Ocelli—Black.

Thorax—Dark fawn.

Abdomen—Dark fawn dorsally: light fawn ventrally. Latero-posterior angles of ninth segment project backwards as sharp teeth. Female has whitish rings at posterior edges of segments. Male has light fawn penes and very light fawn three-jointed claspers, which become almost colourless distally.

Caudal setae—Fawn, black-ringed at joints. Male: median one, 11 mm.; outer ones, 9 mm.; female: median ones, 9.5 mm.; outer ones, 8.5 mm.

NYMPH.

Length (excluding setae)—8 mm.

Body—Compressed dorso-ventrally.

Head—Quadrangular: the latero-anterior corners are rounded. Ocelli dark brown.

Eyes of female, olive; of male, upper lobes brown, lower lobes olive.

Antennae—Filiform; pale at base, the segments becoming darker, narrower and longer distally with a whorl of short hairs at each joint.

Mouthparts—*Labrum* (Text-Fig. 20)—More than three times as wide as it is long: strongly chitinised. The posterior border is slightly convex—not nearly so much as is the border of an Atalophlebiid labrum. The lateral borders are markedly convex, the anterior one, only very slightly so, and with a slight median concavity viewed dorsally, which deepens to a pronounced 'V' when viewed ventrally, forming therefore a trough of increasing depth dorso-ventrally in front of the labrum.

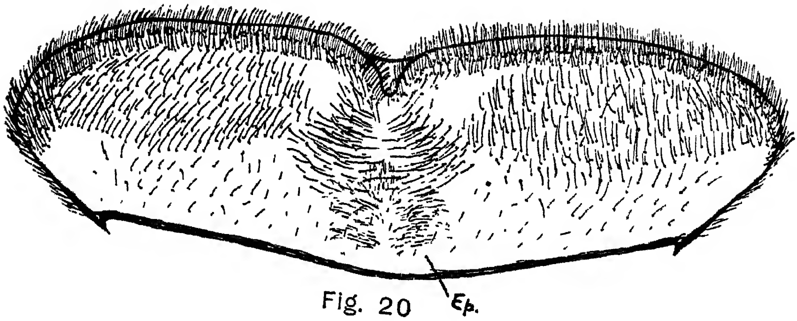


Fig. 20

Fig. 21

Nymph of *Deleatidium vernale*.

FIG. 20.—Labrum. × 85.
FIG. 21.—Maxilla. × 60.

Rows of spines occur on and near the anterior and lateral margins and scattered over the dorsal and ventral surfaces, profusely so anteriorly. In the anterior portion there is a row of rather large inwardly-directed spines on each side of the median line, extending from half way to near the anterior border. In the space between the rows of spines (i.e. medianly) lies a tongue-shaped cluster of smaller ones, with the apex of the tongue directed anteriorly. A larger tongue-shaped cluster of longer but thin spinose hairs, the epipharynx, is placed medio-posteriorly.

Maxilla (Text-Fig. 21)—Palp three-segmented: the middle segment is broader and slightly longer than the other two. There is a fringe of long hairs on the exterior margin of each segment and a few spines on the distal half of the interior edge of the middle one. These spines continue up the interior edge of the apical segment, which is acuminate and densely covered with medianly-rooted, longitudinal rows of spinose hairs with recurved tips. The maxilla terminates anteriorly in a broad brush of thick brown hair: starting from the interior corner, half a row of pectinate rakes is rooted ventrally near the anterior edge—the distal parts of these rakes do not show against the background of the aforementioned brown brush. The interior edge of the maxilla is fringed with long hairs, which become shorter anteriorly.

Mandible (Text-Figs. 22 and 23)—Outer and inner canines (o.c. and i.c.) each with three teeth, which are minutely serrated. The edges of the canines are also serrated and one large serration on the outer canine gives it, in some specimens, the appearance of having four teeth. Prostheca (p) slender, slightly chitinised, with brush of light brown bristles, which are a trifle longer than the prostheca, at base: the latter is about three-fifths the length of the inner canine and has serrated edges. Molar surface (m) with about nine parallel ridges, armed with tufts of bristles.

Hypopharynx appears identical with that of an Atalophlebiid nymph.

Labium (Text-Fig. 24)—Palps three-segmented. The basal and median segments are about equal in length: the apical one is less than half as long. The basal segment, which is the broadest, bears spines on its convex, lateral edges and a few scattered ones elsewhere. The median segment has a straight inner edge and a convex outer one: it bears a few scattered, thin spines. The distal segment is pyramidal in shape, with a number of stout spines, which become more numerous apically; these latter have recurved tips. Paraglossae very wide. Their posterior edges slope anteriorly towards the internal corners so that their greatest length is at the exterior edges: they are profusely haired anteriorly. Glossae only about one-third as wide as the paraglossae; narrowing anteriorly: covered all over, except at the extreme posterior, with dense hair.

Thorax—Varying in colour: olive brown, reddish-brown, or light brown.

Segments rather broader than those of the abdomen.

Prothorax about one-third as long as it is wide, meso-thorax twice as long, meta-thorax about as long as pro-thorax. On many

Fig. 24

Fig. 22

Fig. 23

Nymph of *Deleatidium vernale.*

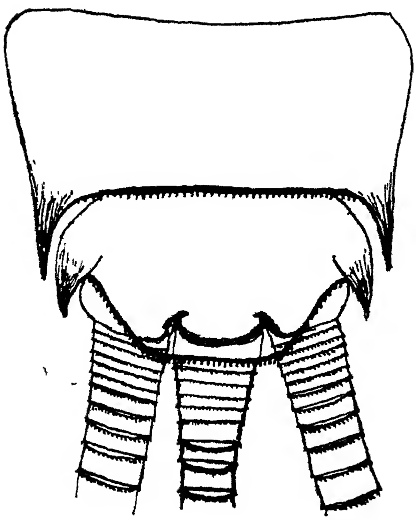
FIG. 22.—Mandible × 45.
FIG. 23.—Canines and prostheca, greatly enlarged.
FIG. 24.—Labium. × 45.

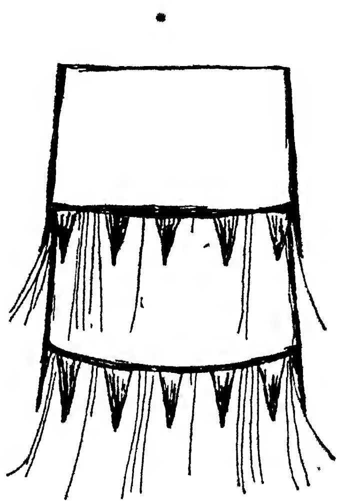
specimens there are two light dots on each segment, one on each side of the median line.

Wing-pads—Large and conspicuous; dark olive; they reach as far as the fourth abdominal segment.

Abdomen—Narrowing posteriorly, more markedly in the last four segments. Posterior edges of segments with very minute backwardly-directed teeth. The latero-posterior angles of the ninth and tenth segments are produced backwards as pronounced teeth. In the other segments these teeth become less and less pronounced anteriorly till in the third segment they are barely recognisable as such. Dorsally, the first eight segments are dark olive with a light triangular marking placed medianly, its apex pointing forward: the ninth and tenth segments are lighter with dark olive lateral edges. Ventrally, the first eight segments are light olive, dark-rimmed posteriorly: the ninth and tenth segments are pinkish-brown.

Caudal setae (Text-Figs. 25 and 26)—Three: outer ones, 9.5 mm.; median one, 11 mm. The colour of the setae is dark in the proximal, light olive in the distal parts, dorsally: ventrally, it is pinkish. Segments become longer and narrower distally with whorls of backwardly-directed teeth and a few spinose hairs at joints.





Nymph of *Deleatidium vernale*.

FIG. 25.—Posterior of abdomen and anterior of caudal setae (dorsal view) × 60.

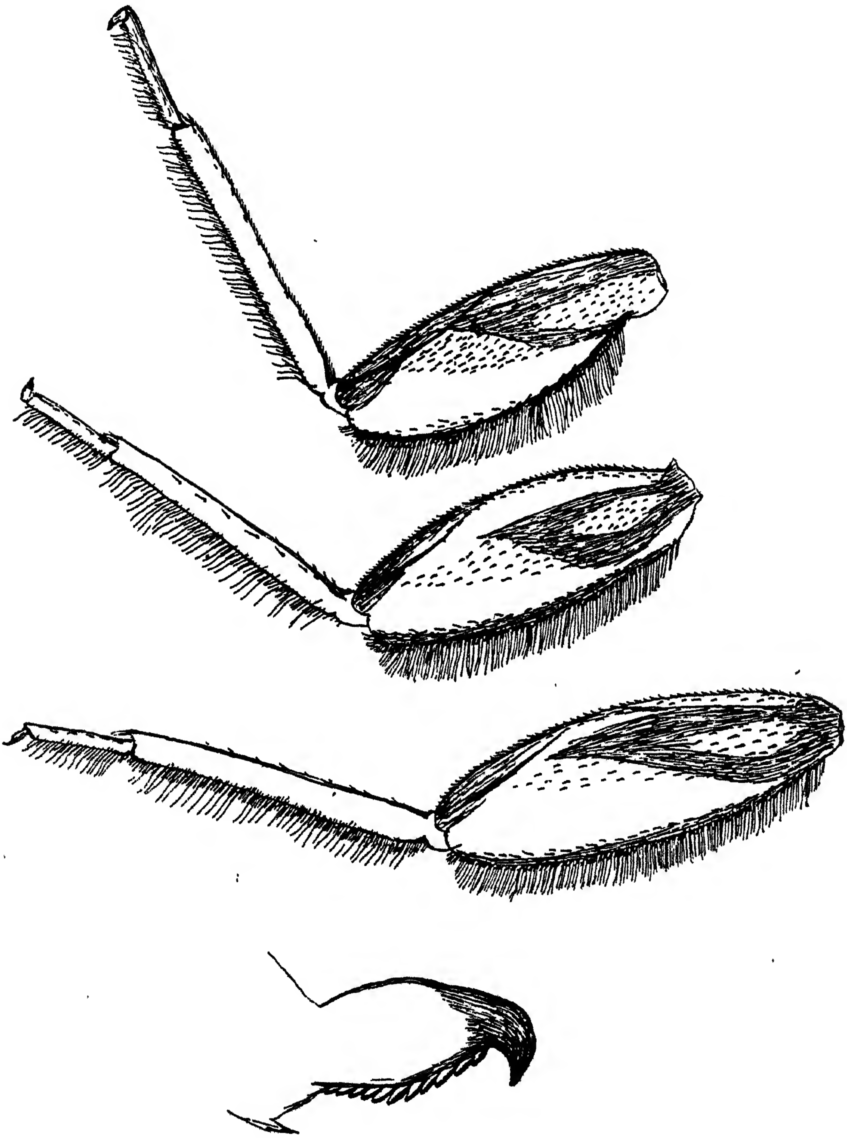
FIG. 26.—Segment of distal part of caudal setae, much enlarged.

Legs (Text-Fig. 27)—Femur flavescent, mottled with light brown as figured. Tibia somewhat darker: tarsus darker still.

The legs increase in length posteriorly. In all the legs, the tibia is somewhat shorter than the femur and about three times as long as the tarsus.

Tarsi decrease very slightly in length posteriorly. In the legs of the first two pairs the tibiae are about equal in length, but in those of the third pair the tibiae are noticeably longer.

The femora of the leg of the middle pair are slightly longer than those of the anterior pair and considerably shorter (about five-sixths) than those of the posterior pair. All the femora are oval and dilated.



Nymph of *Deleatidium vernale.*

FIG. 27.—Legs. × 30, and tarsal claw, greatly enlarged.

The dorsal edges of all three joints bear a fringe of hair on each leg. A number of rows of spines occur on the dorsal and ventral edges of the femora and along a median tract on both the anterior and posterior surfaces. Spines also occur sparsely on the tibiae, but mainly along the ventral edge and a few on the tarsi—ventrally in the case of the two hinder pairs, anteriorly and posteriorly on the anterior pair.

Claws—Sharply curved and pointed at tip, which is darker than the rest of the claw. Ventrally there are a number of small teeth.

Note: In the legs of the specimen figured, the claws were turned round: in life, they should face in the opposite direction.

Gills (Text-Fig. 28)—Pairs of gills are borne laterally on the first seven abdominal segments. Those of the first pair are reniform with pointed apices: the gills of the other pairs are ovate-acuminate; they become smaller posteriorly.

Each gill consists of a flat, almost colourless, lamella: the black tracheal venation is pinnate.

Considerable ramification of tracheoles is visible between the tracheal branches. The lamella surface is covered with pits. At intervals, all round the edges of the gills, are a number of very minute sensillae (not shown in figure).

The gills are vibrated at a moderate speed for short periods, alternated by periods of rest.

The apical points are longer and more acute than those of the gills of *D. lillii* and the lobe of the kidney-shaped anterior gills has a less pronounced salient.

Distribution—Tributary of the Kaiwarra Stream at Ngaio and Khandallah, near Wellington.

Deleatidium lillii (Walker).

The winged stages of this species were first described by Walker (24) under the name of *Baetis scita,* then by Eaton (17) as *Leptophlebia scita* and again (4) as *Atalophlebia scita* and finally (5), when further specimens were sent, together with some of the nymphal stage, as *Deleatidium lillii.*

Lillie (3) also described all stages as *Atalophlebia scita,* subsequently (18) quoting Eaton's (5) description of the winged stages and his renaming of the species.

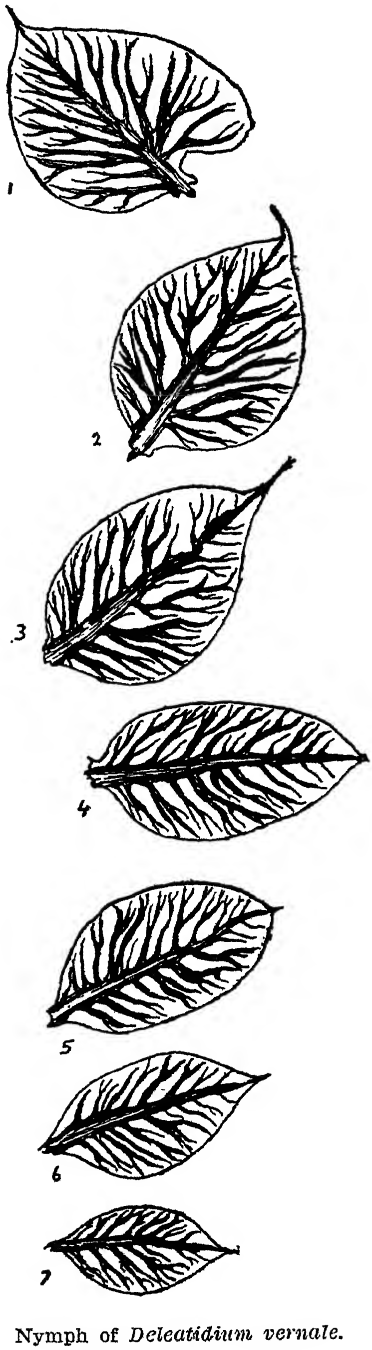
As the male genitalia are well figured by Eaton (5) and also by Lillie (3) and the latter has also illustrated the venation, head and legs of the adult as well as the legs, mouthparts and general appearance of the nymph, only photographs of the imaginal and sub-imaginal wings are included here. (Pl. 67, Fig. 17 and Pl. 63, Fig. 7).

Nymph—Apparently practically identical with that of *D. vernale,* described above. The gills are illustrated (Pl. 64, Fig. 11), for comparison with those of *D. vernale.*

The photograph of the nymphal exuvia (Pl. 63, Fig. 10) is of *D. lillii,* but it would represent equally well the nymphal exuvia of either *D. vernale* or *D. autumnale.*

Imago—Length, 8.5 mm. (excluding setae).

Head—Umber brown.



Nymph of *Deleatidium vernale*.
FIG. 28.—Gills. × 25.

Eyes of female dark olive; of male, upper lobes reddish-brown, lower lobes dark olive.

Thorax—Shining umber brown.

Abdomen—Reddish-brown, becoming rather more reddish distally: anterior parts of segments are more deeply tinted than posterior. 'Segments three to six are sometimes transparent and whitish at the base. Female has ventral lobe of ninth segment slightly emarginate with acute points.' (Eaton).

Penes—Light brown.

Claspers—Light brown, distal joint almost colourless: three-segmented, dilated basally.

Caudal setae—Fawn with dark brown joinings; basally, some of these are alternately broad and narrow. Median seta: male, 17 mm.; female, 13 mm.; outer ones: male, 15 mm.; female, 12 mm.

Legs—Anterior pair: femora sepia brown, tibiae lighter brown: tarsi fawn. Other pairs: femora raw umber, tibiae and tarsi very light brown. There is a dark mark at the 'knee' of each leg, covering the distal end of the femur (where there is also a prominent spine ventrally) and the proximal end of the tibia. Tarsi four-segmented. Tarsal claws unlike; the outer ones being broad and blunt, the inner narrow, curved and hooked at tip.

Wings (Plate 67, Fig. 17)—Expanse: male, 19 mm.; female, 22 mm.

"Male—Vitreous with pitch black neuration, except in the fine cross-veins of the marginal and sub-marginal areas that precede the pterostigmatic region (which are deficient in colouring) and the roots of the stronger nervures interior to hm., which are raw umber brown: the membrane at the extreme roots is almost imperceptibly tinted raw umber or greenish. In the marginal area of the forewing, before the bulla, are usually about six faint cross-veins, and beyond that three to four faint and eight to eleven stronger veinlets, all simple.

"Female very like the male, but colouring at forewing roots, interior to hm., is rather darker. Marginal area of forewing contains three to five faint cross-veins before the bulla and two faint and thirteen strong beyond, all simple." (Eaton).

Eggs—These are regularly oval, with broad rounded ends. The chorion is covered with bosses, at regular intervals, in the form of discs with central craters. There are no attachments apparent.

Sub-Imago—Wings (Pl. 63, Fig. 7)—"Uniformly light grey, with opaque neuration." (Eaton).

Two other species of New Zealand mayflies have plain grey wings, *D. fumosum*, n. sp. and *D.* (*Atalophlebioides*) *cromwelli*, n sp. The last-named, however, has pearly-grey wings, whilst both the *Deleatidium* spp. have smoky or bluish-grey ones.

The present species, *D. lillii*, is somewhat larger than the other two, having a wing-spread of about 20 mm. as against 15 mm. in the other species.

The head is greyish; the thorax greenish-brown; the abdomen fawn dorsally, edged with dark grey on posterior and lateral edges of segments; ventrally, it is reddish-brown with the posterior three segments dark fawn, in the case of the female, while the male has the anterior and posterior three segments umber brown and the median ones greenish-grey. In the anterior pair of legs, the femora and tibiae are olive brown and the tarsi grey; in the other legs, the femora are light brown, the tibiae flavescent and the tarsi light grey.

Distribution—Auckland, Hawkes Bay, Wellington, Nelson and Canterbury provincial districts.—*Lillie,* Dunedin.

Deleatidium autumnale n. sp.

This fly emerges during the summer and autumn. It is very common in March and April, often appearing in large numbers, about sunset, on the Hutt River.

The nymphal and imaginal stages are easily confused with those of the two insects described previously, but the sub-imaginal stage is quite distinct.

Imago — *Length* (excluding setae) — Male: 8.5 mm.; female, 7.5 mm.

Head—Light brown.

Eyes of female, dark olive; of male, upper lobes dull orange red, lower lobes dark olive.

Ocelli—Dark brown.

Thorax—Pronotum light brown: meso- and meta-notum dull raw umber: notal shield with a diagonal light yellow line on its latero-anterior margins.

Abdomen (female)—Dorsum light brown, shaded in the median and lateral portions with dark grey markings, more heavily so in the anterior segments: the first eight segments are light-rimmed posteriorly. There is a pair of light coloured dots placed medio-anteriorly on the first seven segments. The latero-posterior angles of the ninth segment are produced backwards as sharp teeth. Male as female, but more heavily shaded with dark grey throughout; lighter markings indistinct or absent; last three segments sometimes with dark reddish tinge.

Penes—Light brown, shaded with grey.

Claspers—Three-segmented, basal segment dilated proximally: light brown, shaded with grey, distal segments short and colourless.

Caudal setae—Grey with dark joinings. Median seta: male, 14.5 mm.: female, 10.5 mm.; outer setae: male, 13.5 mm.; female, 9.5 mm.

Legs—Anterior femora and tibiae, burnt umber. Hind femora, dull light raw umber: hind tibiae flavescent. Tarsi, light grey (except male fore-tarsi, which are nearly colourless): four-segmented. Claws dissimilar; the outer ones being broad and blunt, the inner narrow, hooked and pointed at tip.

Wings—Wing-spread, 16 to 17 mm. Length of forewing, 7.5 to 8 mm. Surface hyaline. Veins C, Sc, R 1, hm. and ptero-stigmatic cross-veins, burnt umber; remaining veins very dark brown or black. Bullae on Sc., R 1 and R 2a. Ptero-stigmatic region sometimes tinted faintly brown.

Eggs as those of *D. lillii.*

Sub-Imago—*Wings* (Pl. 63, Fig. 8)—Surface cloudy-flavescent, shaded with grey irregularly by the borderings of the cross-veins. Veins grey, except C, Sc., and R 1, which are dull brown. Wing-base brown.

Nymph—*Length* (excluding setae)—Ca., 8.5 mm.

Description as for *D. vernale,* but in the dorsal view of the abdomen, instead of the yellow triangles, there is a narrow median longi-

tudinal band, which broadens appreciably in segments five and six, narrowing again in segment seven and broadening slightly in the anterior part of segment eight: the posterior three-quarters of segment eight is yellow, as are the whole of segments nine and ten, the tenth being somewhat lighter than the others. There is a pair of light yellow dots—placed about half way from front to rear, one near each of the lateral margins—on the fourth, fifth, sixth and seventh segments.

Distribution—R. Waikanae and R. Hutt, Wellington district.

Deleatidium fumosum n. sp.

In autumn and late summer—most noticeably in March and April, there appears on the water a fly, which may be called the 'little blue dun.'

For a long time I believed it to be a small, late-seasonal variety of *D. lillii*. It was also confused with *D.* (*Atalophlebioides*) *cromwelli*, a fly of very similar appearance and size, but with sub-imaginal wings of a rather lighter shade of grey.

When, however, it was found that this 'little blue dun' emerged from an exuvia with single gills, whereas the nymph of *D. cromwelli* has double ones, it was recognised that it must be another species.

Owing to the fact that a few *D. lillii* sub-imagines of the normal size were found during the autumn, I have come to the conclusion, lately, that the smaller fly is a distinct species: since arriving at this opinion, I, unfortunately, have had no opportunity of breeding these flies separately: it would be desirable to do this so as to confirm the belief that these are two separate flies.

The nymph has not been identified with certainty, as it resembles a nearly full-grown specimen of *D. lillii.*

A comparison of the exuviae, cast by the two sub-imagines show various small differences.

The length of the present species is 7 mm. (cf. *D. lillii* ca. 9 mm.). There is a broad, yellow, median, longitudinal line dorsally and a pair of dots, one on each side of this line, on the first seven abdominal segments. The eighth and ninth segments are mainly yellow, but each has a narrow, grey strip anteriorly. The tenth segment is grey. Latero-posterior angles of the ninth segment are produced backwards as sharp teeth. The outer caudal setae are 8.5 mm. long.

Imago (male).

Length—6.5 mm., excluding setae.

Head—Dark reddish-brown.

Eyes—Upper lobes orange red, lower lobes very dark brown.

Thorax—Dark burnt umber, lighter laterally.

Abdomen—Reddish-brown, median segments lightest: segments dark-rimmed posteriorly: venter lighter.

Penes—Reddish-brown.

Claspers—Reddish-brown, becoming lighter distally; three-segmented.

Caudal setae—Dark brown with black joinings: median one, 10.5 mm.; outer ones, 9.5 mm.

Legs—Anterior pair: femora and tibiae, dark burnt umber; tarsi, dark grey. Other pairs: femora and tibiae, raw umber; tarsi, dark grey. All femora with dark mark distally. Tarsi four-segmented. Tarsal claws dissimilar.

Wings—Length of forewing, 7.5 mm.

Surface hyaline, veins dark brown, C., Sc., R 1 and hm. appearing somewhat lighter but stronger. Bullae on Sc. and R 2a. Pterostigmatic area with very faint brownish tinge, sometimes extending along costal region.

Egg—This is similar in shape and sculpturing to the eggs of *D. lillii* and *D. autumnale,* but differs in that it is covered by a thin mucilaginous layer.

SUB-IMAGO.

Wings—Smoky-grey throughout.

It may be distinguished from *D.* (*Atalophlebioides*) *cromwelli* in that the wings are of a darker shade, the cross-veins are black, not colourless, and the abdominal segments are *not* markedly dark-rimmed posteriorly, as in the latter species, but have, instead, dark crescent-shaped markings on each segment.

Distribution—Streams round Wellington.

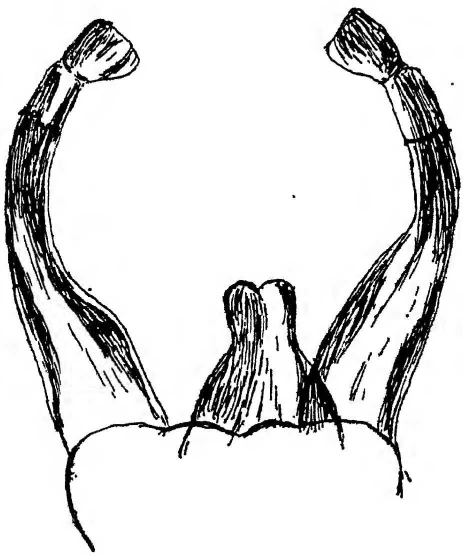
Deleatidium myzobranchia n. sp.

IMAGO.

Length (excluding setae)—8 to 10 mm.

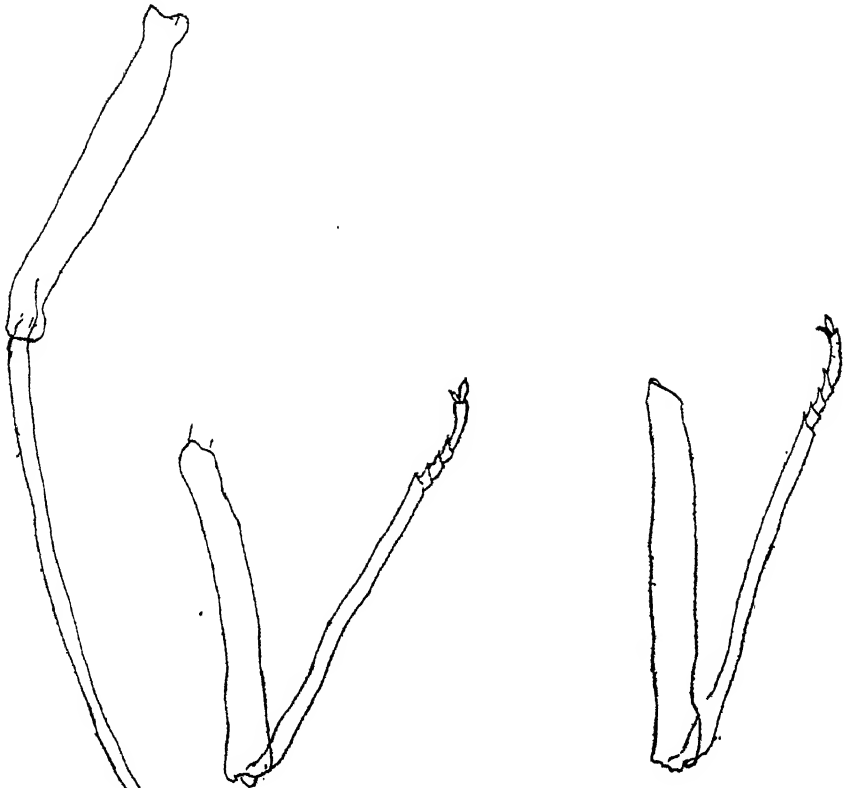
Head—Eyes—Male has upper lobes light brown, lower lobes olive; female, olive.

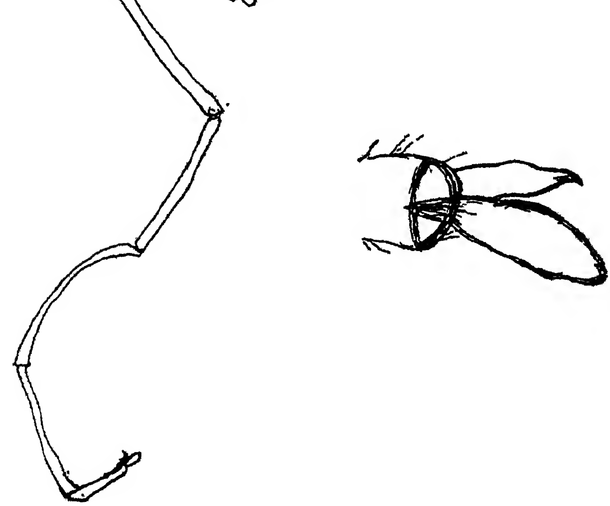
Thorax—Chestnut brown.



Deleatidium myzobranchia.

FIG. 29.—♂ Genitalia. × 24.





Deleatidium myzobranchia.

Fig. 29a.—Legs of ♂ Imago. × 20, and tarsal claw, much enlarged.

Abdomen—Dorsum—Brick red with black markings, first four segments darkest.

Venter—Pinkish, ringed with black at ventral edges of segments.

Penes and forceps (Text-Fig. 29)—Brown, the forceps being three-jointed and dilated in the proximal joint.

Caudal setae—Brick-red at base, the light fawn, ringed with black at joint; median seta 15 mm., outer ones 13 mm.

Legs (Text-Fig. 29A)—*Femora*—Light brown, darker distally.

Tibiae—Male, pinkish-brown; female, yellowish-brown.

Tarsi—Male almost colourless, female grey.

Claws—Brown.

The hind tibiae are about three times as long as the tarsi.

Wings—Forewing—Wing surface hyaline, light brown at base: the costal and sub-costal regions are rose-madder pink, the entire region in the case of the female, the distal quarter only in that of the male. The venation is brown.

Wing expanse—Male, 22 mm.; female, 25 mm.

Hindwing—Very small.

Hyaline, except wing-base, which is light brown; venation dark brown.

Egg—Markings as in other *Deleatidium* Eggs, but outline far more irregular.

SUB-IMAGO.

Head—Eyes—Male has upper lobes brown, lower lobes olive; female, olive.

Antennae—With thick light brown basal segment.

Thorax—Brown.

Abdomen—Dorsum—General colour chestnut or lighter red, shaded with black at lateral and posterior edges of segments and throughout the seventh and eighth segments.

Venter—Light reddish-brown with slightly darker band at posterior edges of segments.

Penes—Light brown; *forceps* light brown; three-jointed, basal joint swelling out pronouncedly towards proximal end.

Caudal setae—Three; light fawn becoming darker distally, with black joinings: median one slightly the longest (11 mm.—outer ones 10 mm.) and about the same length as the rest of the insect.

Legs—Femora—Dull brown, anterior pair rather darker than rest.

Tibiae—Somewhat lighter than femora.

Tarsi—Grey; four-segmented: claws brown.

Wings (Pl. 64, Fig. 12)—*Fore*—Surface opaque, faintly tinged with pale yellow: anal region greyish: the anterior end of wing-base and the distal third of costal region are tinted faint rose-madder pink. An irregular portion in the middle of the wing is devoid of cross-veins and thus has the appearance of a light coloured blotch. No bulla present. The seventh cross-vein from the wing-tip between C and Sc is forked and resembles a wishbone in shape, the other cross-veins are simple.

Hindwing—Colouring similar to forewing: very small.

Nymph.

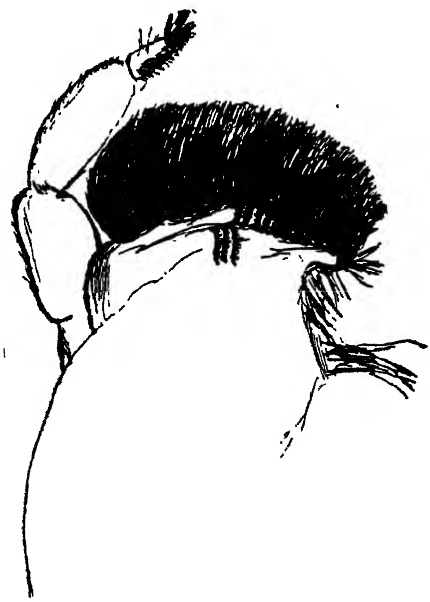
The nymph of this insect (Pl. 65, Fig. 13) lives in moderately-flowing parts of streams and is found on the surfaces of pebbles and boulders.

Its distribution is widespread but somewhat localised. It is full-grown in late spring or early summer, and the imago is one of the first mayflies to appear.

The gills of the nymph are of especial interest, inasmuch as the way they are held shows affinities to Eaton's *Ecdyurus* type, but they have no branchial fibrils.

In nearly all other respects, the nymphs resemble very closely other species of the genus *Deleatidium*—as do the winged stages, with certain minor differences.

Accordingly, the name *D. myzobranchia* (sucker gills) is suggested for this mayfly.



Nymph of *Deleatidium myzobranchia.*
Fig. 30.—Right maxilla. × 60.

Description.

Head—Short, oblong, dark umber brown. Antennae light brown, filiform, as long as head and thorax. Eyes—female, olive; male, upper lobes brown, lower lobes olive.

Labrum (Text-Fig. 35)—It is four times as wide as it is long. The lateral flanges are extended outwards in a sharp curve and are fringed with fine hair, but only slightly so in their posterior parts. The anterior margin is recurved medianly and is very densely fringed with fine hair. There are a number of spines on the anterior half of

both dorsal and ventral surfaces, mostly directed inwards, and two median patches of similar but rather larger spines.

The posterior lateral angles are obtuse and the posterior margin almost straight.

Maxilla (Text-Fig. 30)—Palp three-segmented, the basal segment is the broadest and bears a few fine hairs: the distal segment is much shorter and narrower than the other two, is pointed apically and densely haired. The anterior edge of the maxilla is fringed with a thick brush of long dark brown hair. Rooted near this edge, ventrally, and almost hidden by the brush are about twenty parallel pec-

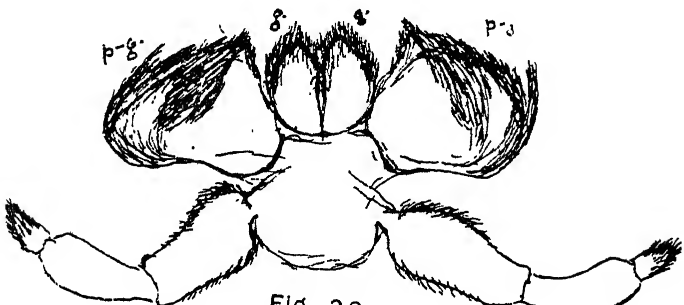


Fig. 32

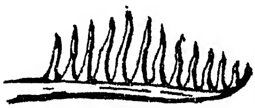


Fig. 31

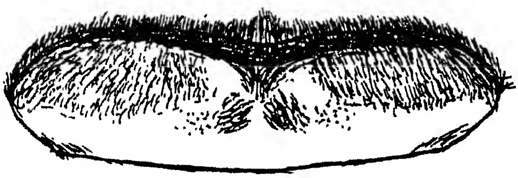


Fig. 35

Nymph of *Deleatidium myzobranchia.*

FIG. 31.—Maxillary rake greatly enlarged.
FIG. 32.—Labium. $\times$ 60.
FIG. 35.—Labrum. $\times$ 60.

tinate rakes (Text-Fig. 31): they occur on the interior half of the edge only. [Two are shown bent back in the maxilla illustrated (Text Fig. 30), as they sometimes are when damaged]. There is a straggly fringe of light coloured hair on the interior edge of the maxilla.

Mandible (Text-Fig. 33)—Outer (o.c.) and inner (i.c.—Text-Fig. 34)—With three teeth; the inmost, in each case, is the largest.

The edges of the teeth are minutely denticulated. The inner edge of each canine is serrated, the serrations being larger than the aforementioned denticulations but smaller than the teeth.

The prostheca (p.) is thin, rather shorter than the canines, acuminate and chitinised apically. The heavy inwardly-directed brush, which accompanies the lacinia in allied nymphs is represented here only by a few short hairs.

The molar surface (m.) bears nine or ten parallel serrated ridges, which are topped by short stiff bristles.

There is a chitinised angular projection on the inside edge of the mandible, below the molar surface.

Hypopharynx—This mouthpart bears a fringe of long brown hair anteriorly. It is similar in shape to that of *Atalophlebia versicolor.*

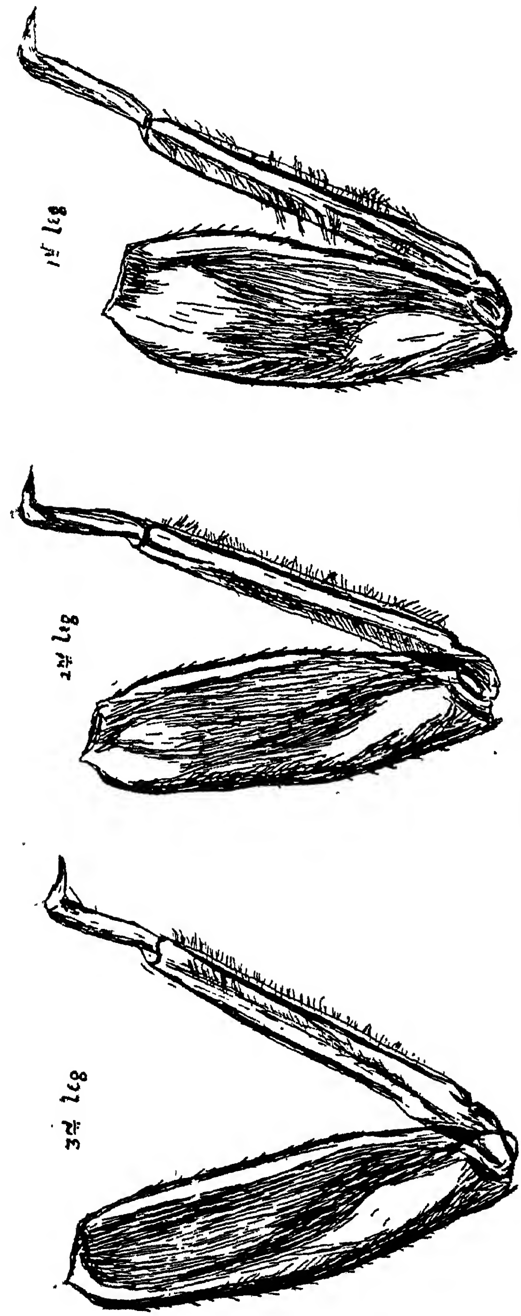
Nymph of *Deleatidium myzobranchia.*

FIG. 33.—Left mandible. × 60.

FIG. 34.—Inner canine of left mandible, very greatly enlarged.

Labium (Text-Fig. 32)—Palp three-segmented; the terminal segment, which is the smallest, is faintly chitinised and is subulate, with a few short spinose hairs. Numerous spines occur on the basal segment, particularly on the outer, and to a lesser extent on the inner, margin. The middle segment is bare or nearly so; it is sub-equal in length to the basal segment but not so stout.

Paraglossae (p.g.)—Dilating anteriorly; the interior and anterior margins are nearly straight, the exterior ones are curved: they are profusely haired anteriorly.



Nymph of *Deleatidium myzobranchia*.
FIG. 36.—Legs × 24.

Glossae (g.)—Much smaller than the paraglossae; narrowing anteriorly: their inner edges touching, their outer edges curved and touching the inner margins of the paraglossae posteriorly. They are densely haired, particularly so at the margins.

Thorax—Prothorax sepia brown, short. Meso- and Meta-thorax umber brown: the meso-thorax is as long as the other two segments combined.

Wingpads—Pitch brown, overlapping the first three abdominal segments.

Legs (Text-Fig. 36)—Umber brown; fairly short; robust; alike. The third pair of legs is the longest, and this is due to their elongated femora: the other two pairs have the femora and tibiae sub-equal and the tarsi one-third as long as the tibiae.

Femora—Thick, ovoid, outer parts translucent. There is a short fringe of hair dorsally and a number of small spines on both edges.

Tibiae—Nearly as long as femora and about one-third as thick. There is a short fringe of hair dorsally and a few irregularly-spaced spines on both edges.

Tarsi—Short. There are a few scattered hairs, mainly at the distal end.

Claws (Text-Fig. 37)—Prominent; light brown; hooked at tip; bent back at right angles to tarsi: toothed below.

Abdomen—Compressed dorso-ventrally.

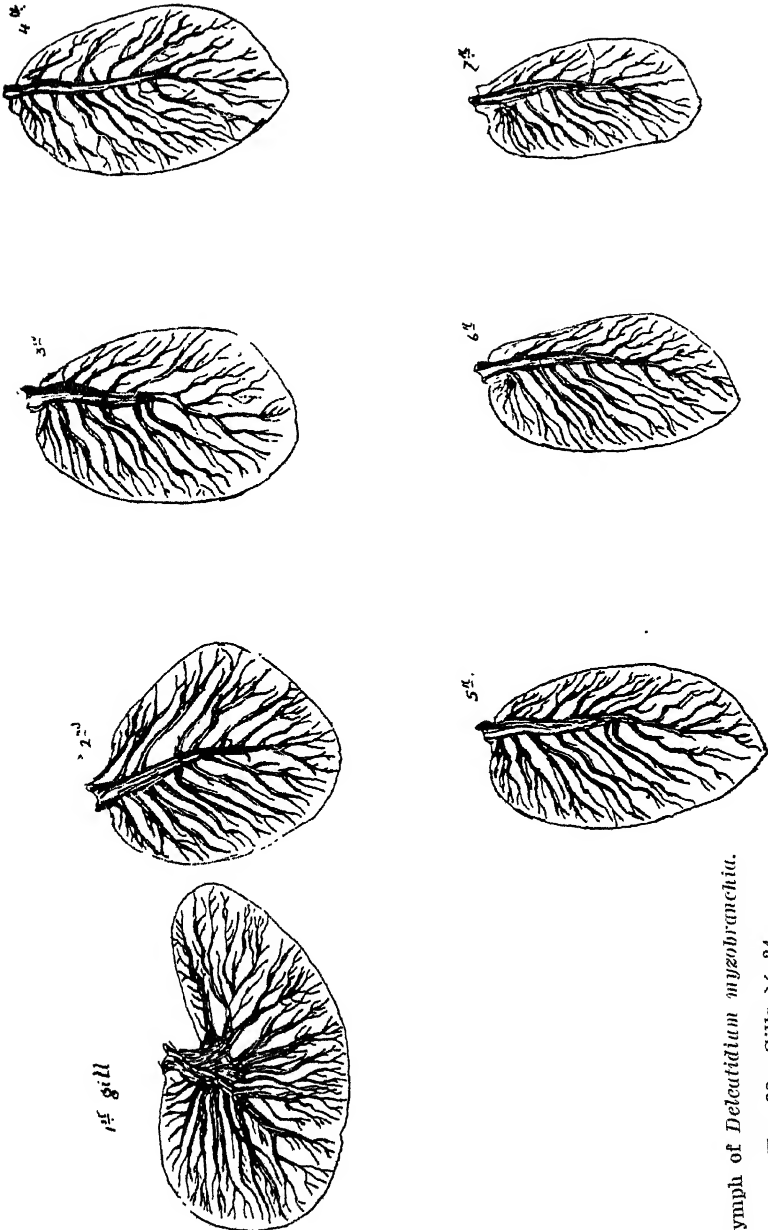
Dorsum—Shining umber brown. Segments with lateral flanges, which are toothed backwards at a point nearly but not quite as far back as the posterior margin. There are irregular light median markings on the first eight segments, broadening out into a triangle, with its apex placed anteriorly, on segment nine. The segments are minutely toothed posteriorly. There are light coloured strips between the terga.

Nymph of *Deleatidium myzobranchia*.
FIG. 37.—Tarsal claw.

Venter—Salmon pink.

Caudal setae—Olive brown, black-ringed at joints. Median seta, 12 mm.; outer ones, 10.5 mm. The posterior edges of the segments are toothed: here and there, one or more of these teeth are replaced by a number of very much smaller teeth, and accompanying each of these is a stiff bristle, which projects backwards.

Gills (Text-Fig. 38)—There is a pair of single lamelliform gills on each of the first seven abdominal segments. Those of the first pair are reniform, the other pairs ovate with rounded apices. The gill surfaces of the hinder pairs become progressively narrower. The colour is flavescent, colourless in parts, with dark brown veining. The venation is pinnate and much ramified. The first six pairs of gills are vibrated slowly: the seventh pair is still.



Nymph of *Deleatidium myzobranchia.*

FIG. 38.—Gills × 24.

When at rest on a stone, the gills are often held against the surface as if they were suckers by which the nymph attached itself to the stone, and possibly they do so assist the insect to hold its position against the current.

The gills of the first pair extend outwards at right angles to the abdomen, but the others extend diagonally outwards at a progressively greater angle backwards and also downwards, so that the seventh pair is held with the lamellae in a vertical plane with the apices pointing backwards.

Distribution—Hawkes Bay, Wellington, Nelson, and Canterbury provincial districts.

Deleatidium cerinum n. sp.

This species transforms during the end of summer and throughout the autumn; it is one of the latest flies to appear and on a fine evening, in early autumn, the male imagines may be found dancing in swarms, fairly low down, and so it may be easily captured.

The sub-imago is very distinct on account of the dead-white, waxen colour of the wings, particularly noticeable as it emerges from the river: if it were not for this colour, it would be very difficult to secure, as it generally transforms at dusk and is, moreover, the smallest mayfly found in this country.

Imago.

Length (excluding setae)—Male, 6.5 mm.; female, 4.5 mm.

Head—Burnt umber. Eyes of female, dark olive; those of male, dark olive in lower lobes, bright orange red, very large and conspicuous in upper ones. Ocelli, light grey.

Thorax—Burnt umber.

Abdomen—Male: posterior four segments brown ochre, except anterior of seventh segment, which is whitish: anterior segments whitish with posterior and lateral edges dark brown. Female: burnt umber, first eight segments dark rimmed posteriorly. Claspers three-segmented, light brown basally, becoming light fawn or flavescent distally.

Penes light fawn.

Caudal setae white, with black joinings.

Legs—Femora luteous with dark mark distally. Tibiae somewhat lighter, also with dark mark distally. Tarsi fawn, dark-marked at joinings. Claws dissimilar.

Wings hyaline and very iridescent. Veins light brown, inconspicuous, C., Sc. and R1 more strongly marked than the others. Cross-veins colourless: hm. not coloured (as it is in *D. cromwelli,* a rather similar fly in other respects, which appears at the same season). Bullae on Sc., R1 and R2a.

Wing length, 6.5 to 7 mm.

The costa, except towards the ends, is less strongly marked than Sc. and R1, giving the wing a particularly fragile appearance.

Egg—Regularly oval; clouded milky; chorion covered with rounded bosses. Egg-mass yellow.

SUB-IMAGO.

Wings—Waxen-coloured: wing-base showing up markedly white. Cross-veins almost invisible. This stage lasts about 24 hours.

The nymph has not been identified for certain, but from the appearance of exuviae, it would seem to be a typical small *Deleatidium* nymph, 5.5 mm. long, with the posterior segments of the abdomen lighter than the anterior ones, small wing-pads, dilated femora, outer caudal seta 6 mm. long, median one 7.5. The gills are single, relatively narrower than in *D. lillii* and more ovate and acuminate in shape.

Distribution—R. Hutt, Wellington district.

Deleatidium (Atalophlebioides) sepia n. sp.

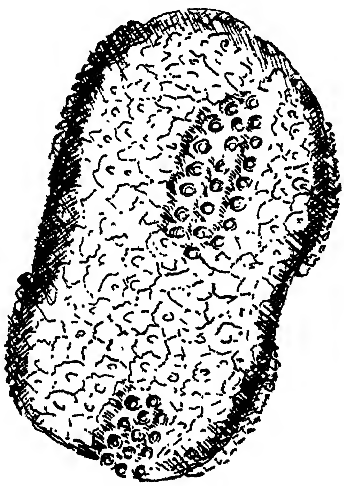
IMAGO.

Length—9-10 mm., excluding setae.

Head—Dingy reddish-brown with black markings.

Eyes of female and lower part of those of male, dark brown; upper part of male's eyes, light brown.

Thorax—Light reddish-brown with black markings: notal shield very dark brown.



Egg of Deleatidium (*Atalophlebioides*) *sepia.* × 320.

Abdomen—Dorsum dingy chestnut brown, venter somewhat lighter: tapering posteriorly: penes and claspers dingy brown.

Caudal setae—Fawn, ringed with brown at joints: median one, 10.5; outer ones, 9 mm.

Legs—Anterior pair: femora and tibiae chestnut brown, tarsi light fawn. Other pairs: femora chestnut brown, also proximal end of tibiae, which become lighter distally; tarsi light fawn. All femora with dark mark distally.

Wings (Pl. 66, Fig. 15)—Forewing surface hyaline, except in costal and sub-costal areas, which are faintly tinged with brown, and wing-base, which is brown. Veins and cross-veins light brown. Hind-

wing hyaline, except for brown area at wing-base between costa and sub-costa. Veins colourless except C. and Sc., which are brown.

Length of forewing, 9 to 9.5 mm.

Egg—Oval with rounded ends, narrowing very slightly medianly, with the circumpolar areas ornamented with minute, truncated bosses: the chorion decorated with hexagonal markings. (Text-Fig. 23 of Pt. 1 of this paper).

SUB-IMAGO.

Wings (Pl. 66, Fig. 15)—Surface of forewing dark sepia grey with brownish tinge (not always perceptible). There is a variety in which this colouring only appears along the main veins, the rest of the wing area being much lighter. The illustration shows this variety. Veins light brown in the costal and sub-costal areas, dark grey in the median and radial ones becoming lighter distally, light grey becoming almost colourless in the cubital and anal areas.

Hindwing light grey, brown at wing-base. Veins almost colourless and transparent.

NYMPH.

This species is found in shingle in the slower parts of streams. It transforms during the later part of the summer.

Length—9 mm., excluding setae.

Head—Shaped like a truncated triangle with rounded corners; dingy olive brown. Antennae as long as head and thorax, thin, composed of a number of uniform beadlike segments; light olive becoming darker distally. Eyes of female and lower parts of those of male black, upper parts olive.

Thorax—Olive brown with darker markings. Wing-pads light olive, large: two pale circular marks with black central dot placed one behind the other on each wing-pad.

Abdomen—Olive brown; last three segments lighter than the rest: inconspicuous light markings and a pair of slightly lighter spots, placed laterally, are found on each of the first eight segments. Lateral edges flanged and slightly toothed backwards.

Caudal setae set at a very wide angle: dark olive, becoming lighter posteriorly: median seta 7 mm., outer ones 6.5 mm. The setae have black joinings.

Legs—Mottled light and dark olive brown: femora very stout with setae posteriorly and a row of setae is also present on the ventral edge of each tarsus. The fore-tarsus and hind-tibia are the longest. Tarsal claw nearly half as long as tarsus, with which it lies in the same line, being curved only at the tip; it is light fawn.

Gills (Pl. 66, Fig. 16)—There are pairs of gills on each of the first seven abdominal segments: the gills of the first six pairs are agitated, those of the seventh are motionless and aborted. Each gill consists of a pair of lanceolate-acuminate lamellae (those of the seventh pair are less acuminate), united basally, each having a broad central trachea running throughout: these tracheae are pinnately branched, the branches themselves being, to some extent, ramified: there are minute hairs around the gill surfaces, more especially distally.

Distribution—Streams round Wellington.

Deleatidium (Atalophlebioides) cromwelli n. sp.

IMAGO.

Length—6.5 mm., excluding setae.

Head—Dark brown. Eyes of female, olive; of male, orange red in the upper lobes, olive in the lower ones.

Thorax—Sepia brown.

Abdomen—Male, sepia brown, second to sixth segments whitish anteriorly, shaded with sepia brown; female, sepia brown in all segments, sometimes with thin, light coloured rim posteriorly on first eight segments. Penes sepia brown. Claspers three-segmented; basal joint dilated, sepia brown; distal joints short and colourless.

Caudal setae white with black joinings, alternately thick and thin in the basal portions. Median one: male, 10 mm.; female, 8.5 mm.; outer ones: male, 9 mm.; female, 7.5 mm.

Legs—Fore-femora and all tibiae, sepia brown; hind-femora, raw umber. All tarsi grey. Claws whitish at base, dissimilar. All segments of the legs have narrow dark mark distally.

Wings—Surface hyaline. Veins dark brown, C., Sc., R1 and hm. prominently coloured: cross-veins colourless and inconspicuous.

Length of forewing, 7.5 to 8 mm.

Egg—Roughly oval, covered with pits and rounded bosses. No attachments apparent. The bosses are smaller, closer together and more numerous than in the eggs of other species.

SUB-IMAGO.

Wings—Uniform pearly grey (smoky grey, when both wings are folded together): wing-base brown. Veins grey and clearly defined, except Sc., R1 and hm., which have a slight brownish tinge. Cross-veins nearly colourless and inconspicuous, thus distinguishing it from *Deleatidium fumosum*, a fly with similar but rather darker wings of the same size but with well-marked black or dark grey cross-veins.

The abdomen is olive brown dorsally, with the anterior of segments 4 and 5 rather lighter: the first six segments are very dark-rimmed posteriorly and there is a pair of light dots, placed medianly on each of the first eight segments.

NYMPH.

The nymph of this fly is very common during the autumn and the latter end of summer: it is then fully-grown and can be found in numbers on the upper and under surfaces of pebbles and small boulders in slow and moderately-flowing parts of streams. The posterior end of the abdomen, which is luteous and in strong contrast to the rest of the surface which is dusky, appears as a luminous dot in sunlight, making this nymph easy to recognise. During the rest of the year, it is only found occasionally, and probably lives concealed in the rubble below the level of the stream-bed. It runs rapidly and seldom swims.

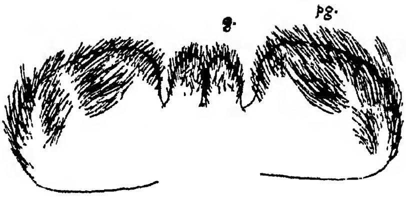


Fig. 44

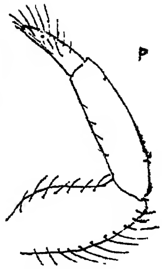


Fig. 45

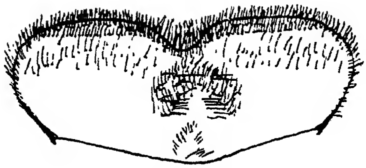


Fig. 39

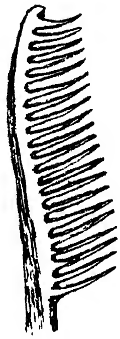


Fig. 41

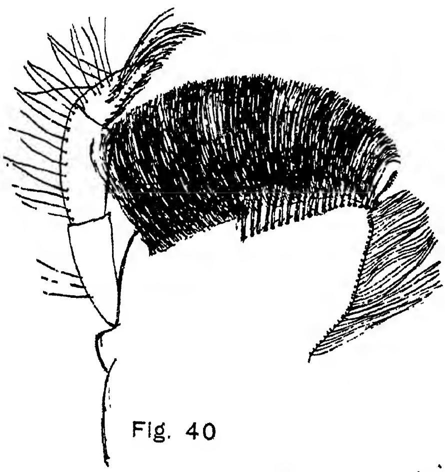
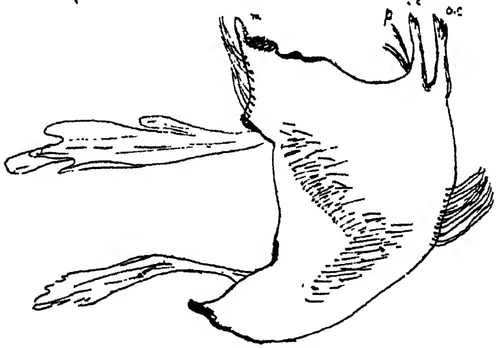


Fig. 40



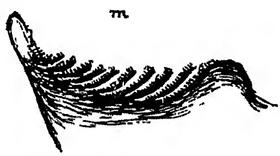


Fig. 43

Fig. 42

Nymph of *Deleatidium* (*Atalophlebioides*) *cromwelli.*

FIG. 39.—Labium. × 40.
FIG. 40.—Right maxilla. × 40.
FIG. 41.—Maxillary rake, greatly enlarged.
FIG. 42.—Left mandible. × 40.
FIG. 43.—Molar surface of left mandible, greatly enlarged.
FIG. 44.—Labium (palps wanting). × 40.
FIG. 45.—Labial palp. × 40.

DESCRIPTION.

Length—7 to 7.5 mm., excluding setae.

Head—Black with three yellow dots, one at each antennal pit and one placed medianly between them.

Eyes of female and of male (lower parts), black; upper parts of eyes of male, dark brown.

Labrum (Text-Fig. 39)—About two-and-a-half times as wide as it is long: anterior border with median re-entrant, posterior border slightly convex, lateral ones markedly convex: all the borders, except the posterior one, are fringed with spinose hairs as is the anterior part of the surfaces: a conspicuous patch of spines occurs anteriorly on each side of the median line and, posterior to these patches, composed of fine hairs, is the tongue-shaped epipharynx.

In the *maxillae* (Text-Fig. 40), the palps are three-segmented: the basal segment becomes broader distally; the median segment is broader and slightly longer; the apical segment is the shortest (about two-thirds as long as the middle one) and pointed at the tip. A row of long hairs occurs on the outer margin of each segment and a dense patch of spinose hairs, their ends somewhat incurved, runs longitudinally along the median area on the apical segment; this segment and the distal part of the middle one have a number of spines on the interior edge. The maxilla terminates anteriorly in a broad brush of thick brown hair: starting from the interior corner, half a row of pectinate rakes is rooted ventrally near the anterior edge; the distal parts of these rakes do not show against the background of the afore-mentioned brush. One rake is illustrated (Text-Fig. 41), greatly enlarged. The interior edge of the maxilla is fringed with long hairs, which become shorter anteriorly.

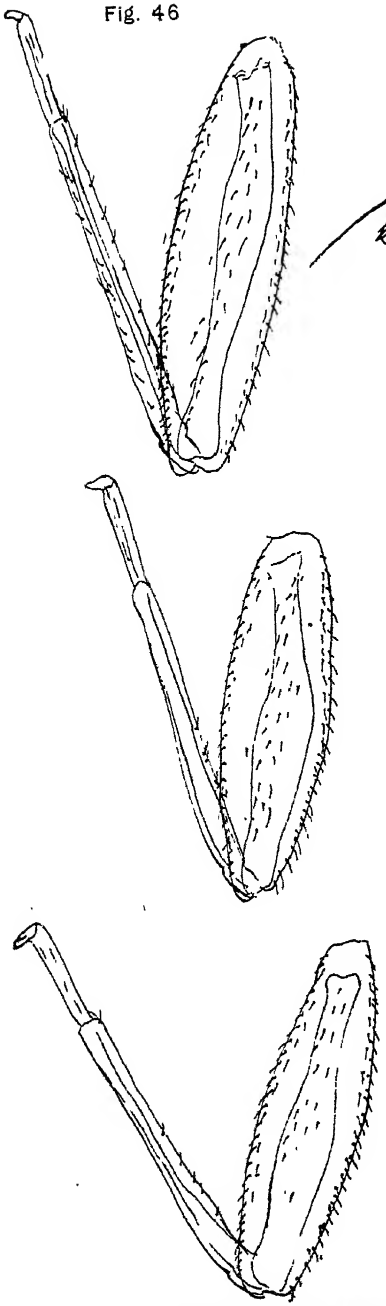
Mandible (Text-Fig. 42)—Outer and inner canine (o.c. and i.c.) and (Pl. 67, Fig. 18) each with three teeth: prostheca (p.) nearly as long as inner canine, thin, acuminate, serrated on inner edge; prostheca brush sparse, shorter than prostheca: molar (Text-Fig. 43) of conventional *Atalophlebid* type, i.e. with about ten parallel rows of serrated ridges with bristle-strainers. There is a narrow fringe of long thin hairs on the posterior part of the outer edge of the mandible and a similar fringe on the anterior part of the inner edge, i.e., proximal to the molar region. A V-shaped patch of spinose hairs occurs on the ventral surface: the irregular attachments shown on the inner edge of the maxilla illustrated are parts of the muscles.

Labium (Text-Fig. 44) and *Hypopharynx*—As in *A. versicolor*, but in the present species, the paraglossae (pg.) are slightly wider and shorter in relation to the rest of the labium and are about five times as wide as the glossae (g.): the labium (without palps) and one labial palp are illustrated (Text-Figs. 44 and 45).

Thorax—Dark fawn with luteous markings: wing-pads black or dark fawn; prominent.

Abdomen—Greatly resembling that of *Deleatidium vernale*: it is much compressed dorso-ventrally: the ground colour is dark fawn

Fig. 46



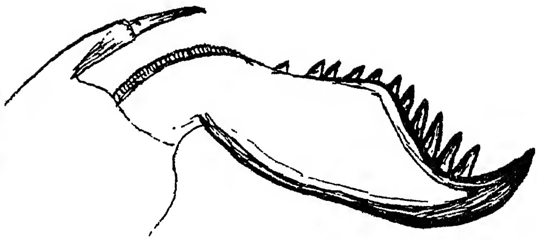


Fig. 47

Fig. 48

Nymph of *Deleatidium* (*Atalophlebiodes*) *cromwelli.*

FIG. 46.—Legs. × 30.
FIG. 48.—Gill. × 30.

FIG. 47.—Tarsal claw, greatly enlarged.

and there is a yellow median line running anterior-posteriorly along the first eight segments; the tenth segment and the posterior two-thirds of the ninth are yellow, as is sometimes the posterior part of the eighth: the segments are flanged laterally and toothed backwards; a luteous dot is placed posteriorly on each flange.

Caudal setae—Light olive with darker joinings: median one longest, 10.5 mm.; outer ones, 9 mm.

Legs (Text-Fig. 46)—The femora are mottled fawn and luteous, as in *Deleatidium lillii,* but they are not so dilated as in that species; the tibiae and tarsi are light fawn. The two hind pairs of legs are equal in length, the tibiae being about three times as long as the tarsi and the femora a shade longer than the tibiae: in the forelegs, both the femora and the tibiae are longer than in the other two pairs of legs. At the distal end of the tarsus, below the claw is a prominent spine. The tarsal claw (Text-Fig. 47) has a number of prominent teeth on the under-side of it. The femora are covered with spines, particularly along the edges and there are a few on the tibiae—rather more numerous on the fore-tibiae.

Gills are placed laterally on each side of the first seven abdominal segments: they are held motionless for short periods alternating with intermediate periods when they are very rapidly vibrated. Each gill (Text-Fig. 48) consists of a pair of lanceolate-acuminate lamellae, united at the base: each lamella has a prominent median trachea, running throughout its length, with short pinnate branching.

Distribution—Streams round Wellington.

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Carpellody in the Wheat Flower and Its Inheritance.

By J. W. CALDER, M.Sc., B.Ag., Canterbury Agricultural College, Lincoln.

[*Issued separately, 23rd August, 1930.*]

THE term carpellody signifies sex-reversal in the direction of male to female organs in plants.

An interesting abnormality of the wheat flower was noticed in a plant among the wheat plots at Lincoln College in 1924. The plant first attracted notice because the glumes remained expanded for from seven to ten days giving the head a conspicuous transparent effect. The abnormality has been investigated and certain experiments have been conducted to determine its behaviour on breeding. The present paper is a progress report of the results.

Carpellody has been reported in various plants and consists of partial or complete transformation of stamens to carpel.

De Candolle reported carpellody in the wallflower (*Cheiranthus cheiri* and he gave the plant the varietal name *C. cheiri gynanthus.* This case has been investigated by Nelson in the *Publications of the Royal Society of Tasmania* in 1928. The stamens adhere together and form a closed ring round the normal carpel. Ovules are produced within this ring and when pollinated produce viable seeds. Nelson crossed a carpellodic form with a normal. The F1 from the cross were normal and segregation occurred in the F2 in the proportion of 3 normal to 1 carpellodic showing that it was a simple mendelian recessive character.

Weatherwax, in the *Proceedings of the Indiana Academy* in 1925 reported carpellody in Maize, where the rudimentary anthers of the pistillate flowers were transformed into carpelloid structures. In this case, however, he states that there is no true ovarian cavity and no ovules are formed although style and stigma are similar to the normal.

Shaffner, in the *American Naturalist* in 1925, when discussing sex differentiation and determination in higher plants, states that sex-reversal is primarily dependent on physiological states, and these are subject to change and reversal through ecological factors.

The wheat flower is considered extremely stable few abnormalities having been reported.

Anthony, in the *Journal of Heredity,* 1918, reports an abnormality in which the anthers bore a few stigmatic hairs and the filament united with the anther as one piece.

Leighty and Sando, in the *Journal of Heredity* in 1923, reported pistillody in the wheat flower and from their description the abnormality is the same as the one here described. They did not give any anatomical description and they state that the character is not

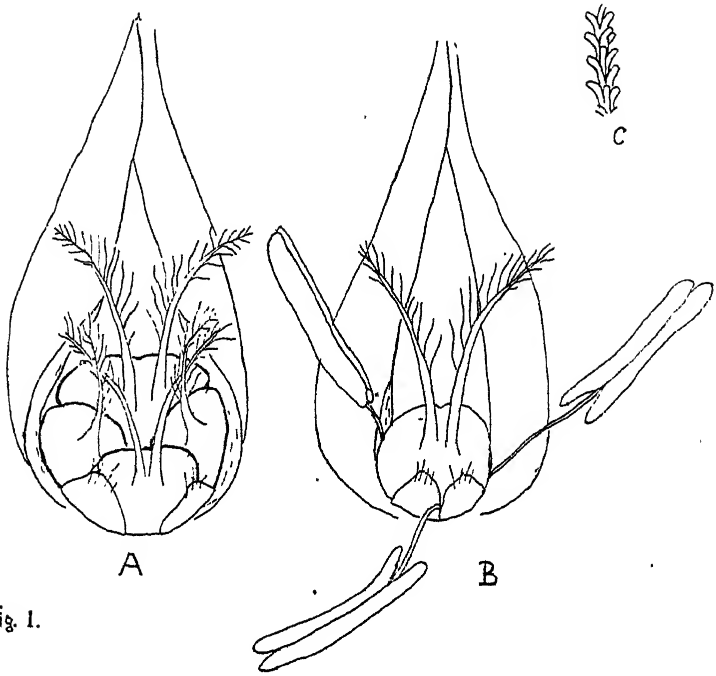


Fig. 1.

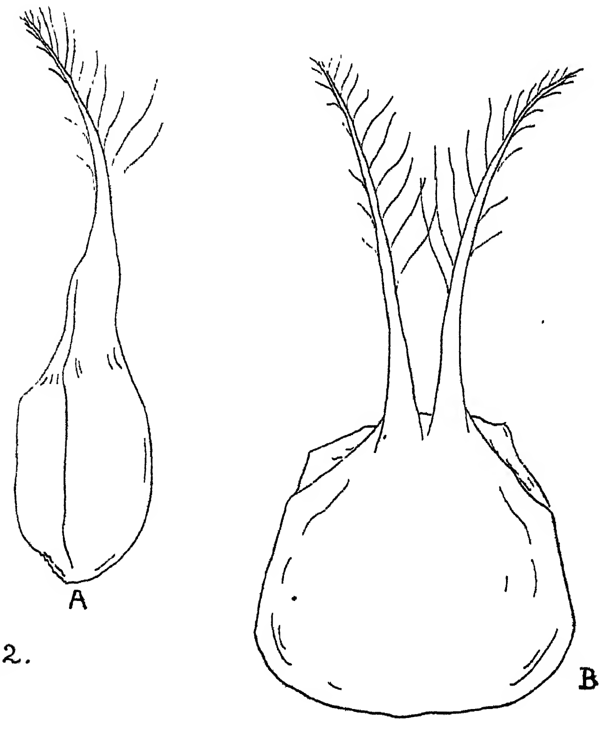


Fig. 2.

inherited as it did not appear among eighteen plants grown from seed of the abnormal plant the next year. They suggest some environmental cause.

In the present paper the anatomical description is given and definite proof that the character is inherited is produced.

In the normal wheat flower there is a central carpel, consisting of a single ovary in which there is a single ovule. There are two distinct style branches which are covered with long stigmatic hairs. Outside the carpel are three stamens—two lateral and one anterior. The stamens have distinct filaments which elongate rapidly at flowering and support definite linear oblong anthers which are devoid of hairs. Outside the stamens are two whorls of structures representing the normal two whorled perianth of Monocotyledons. The inner whorl is represented by two scale like structures in front at the base called lodicules. The outer whorl is represented by a single large member posteriorly—the palea. The above constitutes the flower proper. In addition there is present in front a large bract or glume, the lemma. There are three to five such florets in a spikelet attached alternately to a rachilla and subtended by two empty glumes. The spikelets, of which there are fifteen to twenty-five, are attached on alternate sides of a somewhat flattened zigzag rachis. This inflorescence is called the head or spike of wheat.

DESCRIPTION OF THE ABNORMALITY.

The abnormality involves the transformation of the stamens into carpelloid structures with no resemblance to anthers, or into structures that are partly anther and partly carpel, or involves simply the addition of a few stigmatic hairs at the apex of an anther. The degree of transformation extended over this very wide range. In some flowers only one anther was affected, in others two, but in the majority of cases all three showed some degree of transformation.

The greatest degree of transformation usually occurred in the lowest floret of a spikelet. The second floret was usually somewhat less abnormal and the third floret still less so.

Those stamens which were only slightly abnormal always produced pollen while some which were almost completely carpelloid showed a small portion of pollen bearing tissue usually at the distal end. Others produced no pollen at all. Any floret which did not produce pollen would not as a rule set seed. Thus the lowest florets of the spikelets which were the most abnormal, produced fewer grains than did the upper florets. For example:—

Seven heads were examined and found to contain ninety spikelets. The following table shows the number of grains that would usually be found in each floret of such spikelets and the actual number found.

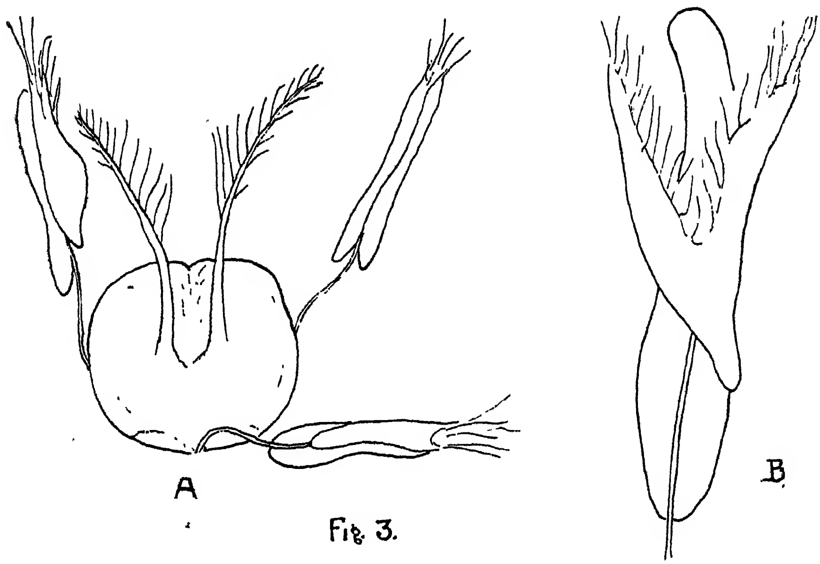


Fig. 3.

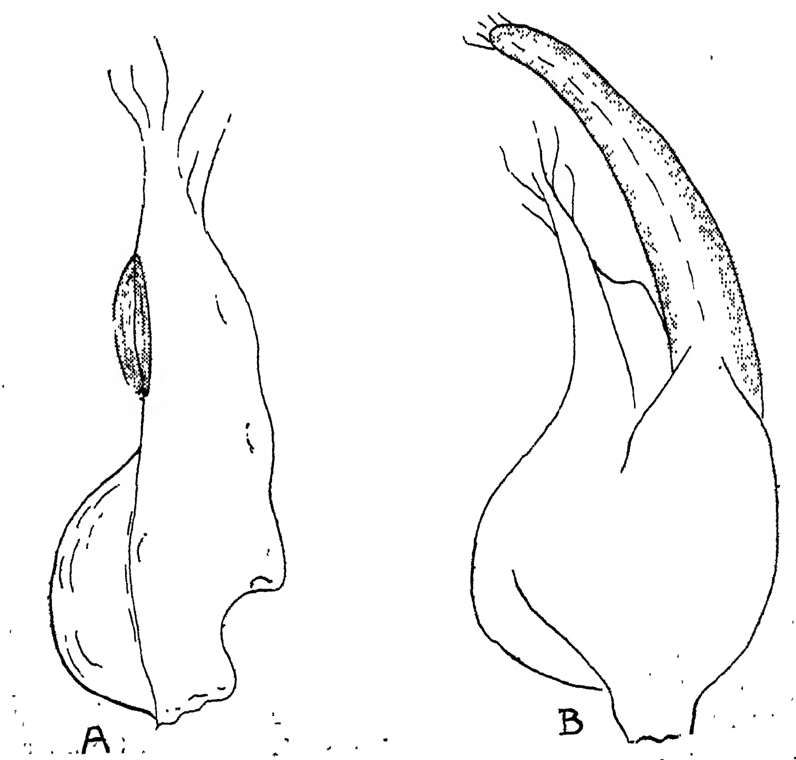


Fig. 4.

Position of Spikelet.	Grains Expected.	Grains Found.	
Lowest	90	9	10%
Second lowest	90	18	20%
Third lowest	36	18	50%
Fourth lowest	7	7	100%

The decreasing percentage obtained from the fourth to the lowest floret is due to the increasing degree of transformation from the fourth to the lowest spikelet.

Fig. 1 B is a diagram of a normal floret; A, is a floret showing the greatest degree of transformation. The anterior abnormal carpel has two stigma branches. C is portion of a stigmatic hair.

Fig. 2 shows A, a lateral, and B, an anterior, abnormal carpel dissected out.

Fig. 3 A is a third floret of a spikelet showing three partly transformed anthers and B is an enlarged view of a single anther.

Fig. 4, two lateral abnormal carpels showing different amounts of carpel and anther tissue. Here the carpel tissue seems to develope chiefly from the filament at A or from both filament and anther at B.

Fig. 5 shows the carpel tissue developing from the anther (A) and from the filament (B).

The question whether the transformation ever extended to perfect carpels was tested by artifically pollinating all the abnormal carpels in one head. No grain set in any of these abnormal carpels thus demonstrating that they are infertile. Further, all the grain which formed in any abnormal head was produced from the central normal carpel. This was evident from the central position of the ripe grain and also from the fact that the ripe grain of the lowest florets, i.e., those in which the abnormality seemed sufficiently advanced to produce grain, had three scale like structures at the base. These represented the shrivelled remains of the abnormal carpels.

An interesting observation was the presence of Ergot in eighty per cent. of the sterile florets. This fungus is very rare on wheat in New Zealand. Adjacent plants in the plots showed no sign of it. Evidently, the fungus is able to gain entrance to the unfertilised ovary more readily than to normally fertilised ones.

Anatomical Description.

Fig. 6 shows, A, a transverse and B, a longitudinal section of a normal carpel. Externally is the massive carpellary tissue which is limited internally by the inner epidermis. Just outside the inner epidermis is a distinct layer of cells which forms the "cross layer" in the ripe grain. Within the inner epidermis is the nucellar cavity. The nucellus arises in the nucellar cavity from the carpellary tissue. It is bounded by a distinct epidermis with its cells elongated at right angles to the surface. Surrounding the nucellus is the two layered inner integument and outside this is the three to four layered outer integument. Occupying the bulk of the nucellus at maturity is the

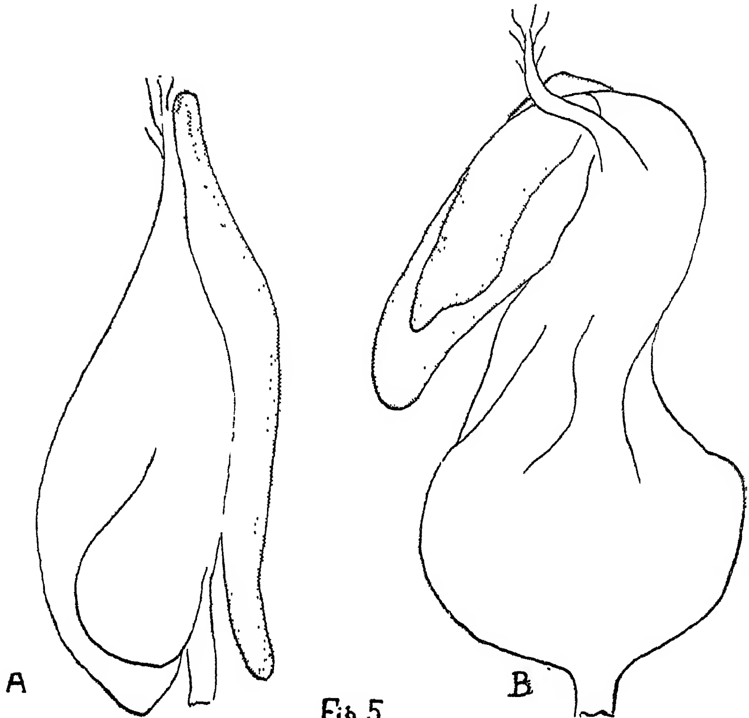


Fig. 5.

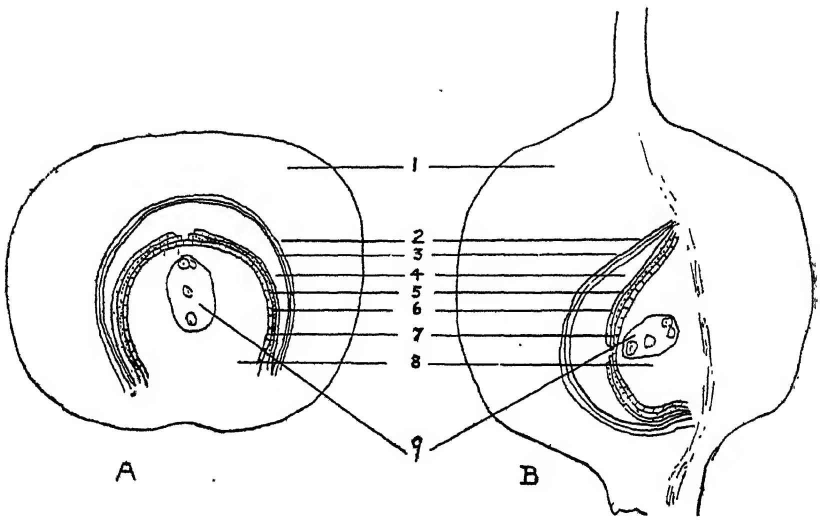


Fig. 6

embryo sac, which arises from a single cell of the nucellus, the megaspore. The embryo sac grows rapidly and is well grown by the time the integuments have closed over the nucellus. So that we have in a normal carpel the following tissues:

1. Carpellary tissue.
2. Cross layer.
3. Inner epidermis of carpel.
4. Nucellar cavity.
5. Outer integument.
6. Inner integument.
7. Nucellar epidermis.
8. Nucellus.
9. Embryo sac.

Fig. 7 is a longitudinal section of an anterior abnormal carpel showing two masses of nucellus with all the tissues one to eight present as in a normal carpel but the embryo sac is missing. The two nucellar masses developing in the abnormal carpel might be of importance in a discussion of the morphology of the grass flower.

Fig. 8 is a diagram of the tissues seen in the abnormal carpel of diagram 7. Exactly similar to those of a normal carpel.

Fig. 9 is another longitudinal section of an anterior abnormal carpel. There are the beginnings of two nucelli (X and Y). The embryo sac and the two integuments are missing, *i.e.*, tissues five, six and nine. The double nucellar masses are correlated with the two stigma branches.

Fig. 10 is a L.S. of a lateral abnormal carpel. Here the nucellus has one nucellar mass with an inner integument composed of several layers of cells and the rudiment of the outer integument. Also in the nucellar cavity are two other outgrowths of tissue without a defined epidermis and do not suggest nucellar tissue. There is no embryo sac *i.e.*, tissue nine is missing, five is rudimentary, six is massive instead of being two-layered.

Fig. 11. This is another L.S. of a lateral abnormal carpel. Here the nucellus has formed near the inner edge of the carpel so that in its growth it has broken through the wall and appears external to the carpel. The inner integument is present adhering close to the nucellus and a portion of the outer integument is present at the apex. There is no embryo sac. In the same diagram are seen stigmatic hairs and a portion of an anther lobe.

Fig. 12 is a L.S. of a similar abnormal carpel showing the nucellus more central but free from carpel enclosure at the apex. Also a portion of anther tissue with pollen grains. Tissues numbered two and three are much reduced.

Fig. 13. A L.S. of a lateral abnormal carpel showing the nucellar cavity appearing as a slit. The inner epidermis of the carpel and the cross layer are present. There is no nucellus or integuments, *i.e.*, tissues five, six, seven, eight, nine are missing.

Fig. 14 is a L.S. of an abnormal carpel showing a reduction in pollen bearing tissue and an increase in parenchyma.

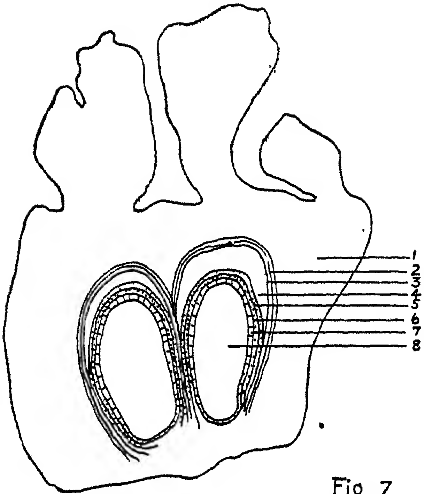


Fig. 7

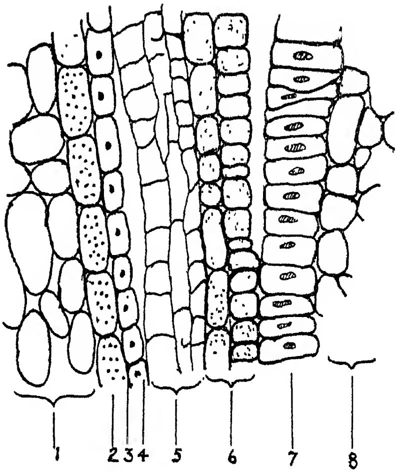


Fig. 8.

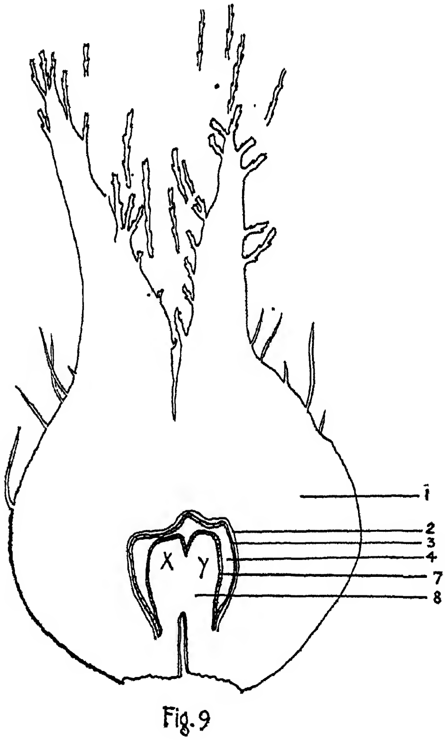


Fig. 9

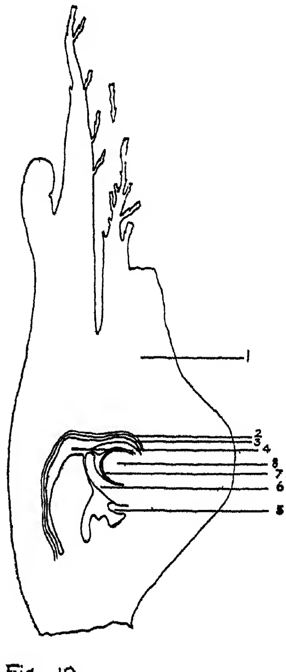


Fig. 10

SUMMARY OF ANATOMICAL STRUCTURE.

A section of the most completely transformed abnormal carpel shows all the tissues present as in a normal carpel with the exception of the embryo sac which was missing in all cases examined. In the anterior abnormal carpel two masses of nucellar tissue develop. Abnormal carpels with less degree of transformation show reduction and suppression of the various tissues numbered one to eight. Tissue nine the embryo sac, is always missing. Anther tissues and nucellus are present in the same structure in some cases. The anther may show an increase in parenchyma with a corresponding decrease in pollen tissue. This parenchyma may develop from the filament or from the anther or from both filament and anther. The lowest degree of transformation was the presence of a few stigmatic hairs at the apex of the anther. Some anthers of the abnormal plant appeared quite normal.

INHERITANCE OF THE ABNORMALITY.

The abnormal plant occurred as one among twenty-five F1 plants produced from a cross between Solid Straw Tuscan and a selected plant from the F4 generation of a cross between White Fife and Benefactor. The remaining twenty-four plants of the cross were normal.

The plant was first noticeable on account of the glumes remaining open throughout the flowering period. This is no doubt due to the extra bulk of the flower and it makes conditions very suitable for cross pollination, which is the only means of pollination in those flowers in which the stamens are sterile. The flower might be accommodating itself for cross pollination.

All of the grain produced by the abnormal plant was sown in the glass house. From fifty-nine grains, some of which were very shrivelled, thirty-nine plants were obtained. These were planted out in the birdcage in the spring and examined at flowering time. Five out of the thirty-nine were abnormal. These were particularly uniform as regards certain morphological characters: they had thin straw, were three to four inches shorter than the other plants of the row, the straw was solid and the heads were of one type. The five plants had the appearance of a pure line. The remaining plants of the plot were very heterogeneous suggesting cross pollination by different parents (this was likely to occur in the plots).

The original plant commenced to grow after harvest so it was transplanted to the green house over winter and planted out again the following spring. At flowering time the abnormality was again present. The plant was weak and no grain was formed. It died after harvest.

BREEDING RESULTS.

A. *Self-pollination.*

Seventeen heads of the five abnormal plants were enclosed in paper bags to ensure self-pollination. One hundred and forty-three grains were obtained and one hundred and thirty-two plants de-

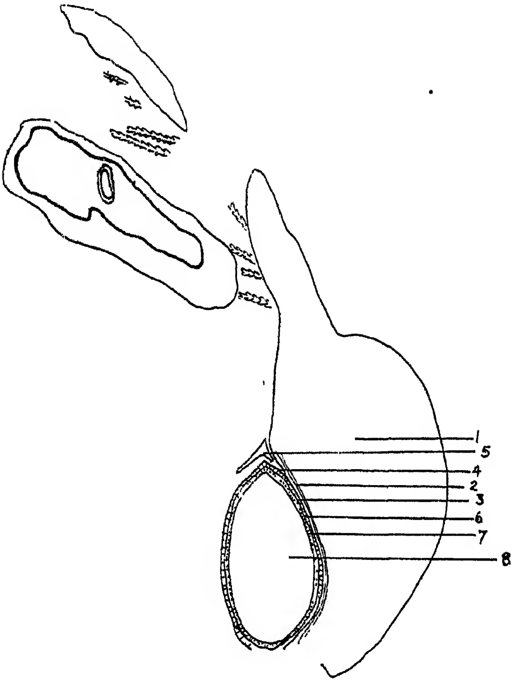


Fig. 11

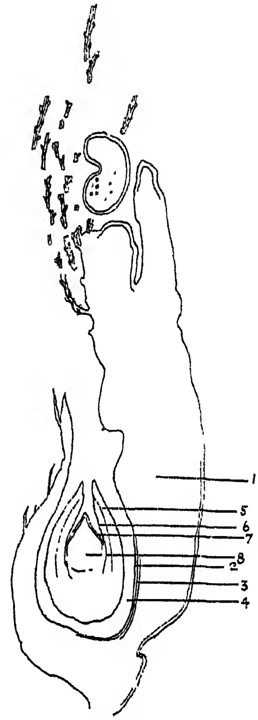


Fig. 12

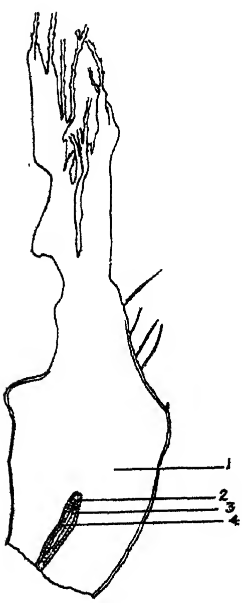


Fig. 13

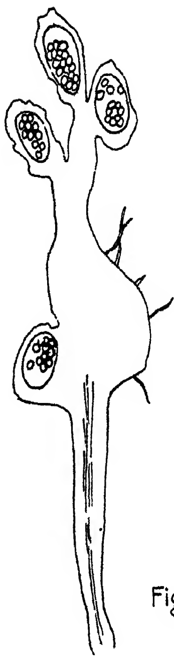


Fig. 14

veloped. Of these, one hundred and twenty-six were abnormal and six were normal. All these one hundred and thirty-two plants (normal and abnormal) were alike morphologically, *i.e.,* they were all short, had solid straw, thin straw, and had similar head type. The presence of the six normal plants is accounted for as follows: As the abnormality was known to vary over a wide range it was thought that these six plants might be masked abnormals. So the seed was sown the next year along with seed from ten abnormal plants. The abnormality occurred among the offspring of five of the six plants to the same extent as it occurred among the offspring of the ten abnormal plants showing that they were masked abnormals. If this is so then the results of self-pollination of the abnormal plants is abnormal offspring. This has enabled the abnormality to be carried on for four generations.

B. *Cross-pollination.*

Five heads of abnormal plants were pollinated with pollen from velvet wheat. Thirty-seven grains were obtained and thirty-four plants developed. These thirty-four F1 plants were normal and had velvet chaff (a dominant character of the male parent). All the grain of these thirty-four plants was sown and 2016 F2 plants developed. Velvet chaff appeared in the proportion of three velvet to one smooth, but not a single plant of the 2016 showed any sign of the abnormality. The abnormality occurred in adjacent plots where the plants were obtained from selfed seed.

The results of the breeding indicate that the character is inheritable and is recessive. It is not a simple recessive as it does not segregate in the F2. It is fairly clear that it is not due to environmental causes. The fact that it also occurred in a single plant in America suggests that it is due to a definite alteration in the chromosomal complex.

The correlation of certain morphological characters with the abnormality are very suggestive of a linkage group and in view of the fact that linkage groups have not yet been definitely located in wheat this abnormality might be of importance in this direction.

Further work on its inheritance is in progress.

Seventh Supplement to the Uredinales and Ustilaginales of New Zealand.

By G. H. Cunningham,
Mycologist, Plant Research Station, Palmerston North,

[*Issued separately, 23rd August, 1930.*]

During the preparation of the manuscript of a book on the Rust Fungi of New Zealand, a critical revision was made of all material in my herbarium. This has led to the erection of several additional species; and to the alteration of the specific names of a few. During the course of the work additional material has come to hand, containing several undescribed species.

These, together with emendations and notes, form the subject of this paper.

Uredinales.

1. **Hamaspora australis** n. sp. Fig. 1.

O. Pycnia unknown.

III. Teleutosori hypophyllous, scattered or crowded in irregular groups, seated on indefinite pallid spots which are visible on the upper surface, elliptical, 0.5-1 mm. diameter, pulverulent, surrounded by the ruptured epidermis. Spores aggregated into pallid yellow fibrils up to 20 mm. or more in length, fading with age, 4-6 celled, long-cylindrical, 100-180 x 14-22 microns; apex strongly acuminate, tapering to a fine sharp point, thickened up to 10 microns, base truncate; not constricted at the septa; epispore hyaline, smooth, 1 micron thick; pedicel persistent, continuous with the spore, tapering basally to a fine point, up to 600 microns long, 10-15 microns thick immediately beneath the spore, hollow; germ pore solitary in each cell, seen only at germination.

Hosts: *Rubus australis* Forst. f. Auckland: Taupo, 400 m. Wellington: Palmerston North, 100 m.; Feilding, 50 m.; Ruahine Range, 1200-1500 m. Nelson: Glenhope, 500 m. Canterbury: Otira Gorge, 500 m., *type collection;* E. H. Atkinson. Peel Forest, 300 m. Otago: Makarora, 280 m. Herekopere Islands.

Rubus schmidelioides A. Cunn. Hawkes Bay: Lake Tutira, 250 m.

Rubus schmidelioides var. *coloratus* Kirk. Westland: Mangles Gorge, 500 m.; Maruia Springs, 700 m.

Rubus schmidelioides × *australis.* Wellington: Feilding, 50 m. Canterbury: Hope River, 700 m.; Boyle River, 750 m. Westland: Maruia Springs, 700 m.

Distribution: Endemic.

All hosts are endemic and not uncommon throughout (Cheesem. 1925, p. 500).

In a previous paper (1924, p. 22) I considered this species under *Hamaspora acutissima.* Since this publication many more collections

have come to hand, and as in all uredospores are wanting, the species is considered to be different, an opinion confirmed by examination of specimens of *H. acutissima* collected in Java, and forwarded by Dr. J. C. Arthur. The pedicels of the spores especially are quite different, those of *H. acutissima* being thickened basally, whereas in *H. australis* they taper to a fine point.

2. **Phragmidium acuminatum** n. sp. Fig. 2.

O.I. unknown.

II. Uredosori hypophyllous, scattered, orbicular, 0.5-2 mm. diameter, pulverulent, orange, encircled by a layer of cylindrical, or clavate, stout, thin walled, hyaline, incurved paraphyses. Uredospores subglobose or obovate, 18-26 x 15-20 microns, average 19 x 16 microns; epispore hyaline, finely and closely echinulate, 1.5 microns thick; germ pores 6-8, scattered.

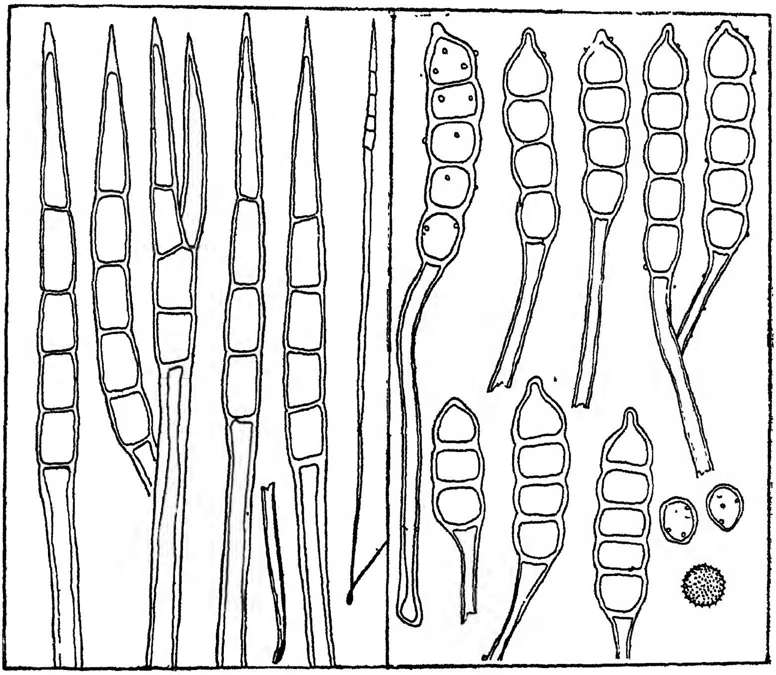


FIG. 1. FIG. 2.

FIG. 1.—*Hamaspora australis* on *Rubus australis;* teleutospores, proximal end of one pedicel shown, × 340. On the right is a spore (× 80) showing the extraordinary length of the pedicel.

FIG. 2.—*Phragmidium acuminatum* on *Acaena Sanguisorbae* var. *sericeinitens;* uredospores and teleutospores, × 340.

III. Teleutosori amphigenous, chiefly hypophyllous, scattered or confluent, orbicular, 0.25-3 mm. diameter, pulvinate, compact, shining black, naked, with numerous spores in each sorus. Spores 1-5 celled, commonly 4, cylindrical, 55-95 x 18-25 microns, average 67 x 20 microns; apex acuminate, drawn into a long coloured papilla, con-

tinuous with the upper cell wall, seldom rounded or papillate, base rounded; constricted at the septa; wall golden brown, smooth, 1.5-2 microns thick; pedicel persistent, continuous with the spore, very long, up to 200 x 4-7 microns, hyaline, hollow, not or but slightly inflated at the base, lower third closely and finely verruculose; germ pores 2-3 in each cell.

Host: *Acaena Sanguisorbae* Vahl. var. *sericei-nitens* Bitter. Canterbury: Cook Range, 700 m. Otago: Routeburne Valley, 500 m.; Table Bay, Wakatipu, 800 m., *type collection;* W. D. Reid.

Distribution: Endemic.

The host is endemic and has a limited distribution in the southern parts of the South Island.

This species was in a former paper (1924, p. 19) referred to *Phr. Potentillae* Karst. I now find that on comparison with material of this European species, our plant differs considerably in numerous particulars, especially in the thin, non-laminated, differently coloured wall, acuminate apex, and fewer number of cells in the teleutospore.

3. **Puccinia mania** n. sp. Fig. 4.

O. Unknown.

II. Uredosori amphigenous, chiefly epiphyllous, small, 0.2-1 mm. diameter, scattered, numerous, ferruginous, surrounded by the ruptured epidermis. Spores subglobose, shortly elliptical or obovate, often somewhat angular, 28-36 x 22-28 microns, average 31 x 24 microns; epispore deep chestnut brown, 2.5-3 microns thick, sparsely and moderately echinulate; germ pores 2 (rarely 3), equatorial.

III. Teleutosori amphigenous, chiefly hypophyllous, elliptical or orbicular, to 2 mm. diameter, scattered, not arranged in lines, pulvinate, compact, dark brown, naked. Spores elliptic-oblong, 52-84 x 14-20 microns, average 66 x 17 microns; apex rounded or bluntly acuminate, thickened to 10 microns, darker in colour, lower cell longer and somewhat narrower; slightly constricted at the septum; epispore sepia brown, 2.5 microns thick in the upper cell, 1.5 microns in the lower; pedicel coloured, persistent, continuous with the spore, to 50 x 10 microns; germ pore of the upper cell penetrating one side of the thickened apex, seldom central, basal pore immediately beneath the septum; paraphyses wanting.

X. Mesospores rare, elliptical.

Hosts: *Carex Berggreni* Petrie. Otago: Kinloch, 370 m.

Carex pyreniaca Wahl. Westland: Mt. Trovatore, 1600 m.

Carex wakatipu Petrie. Westland: Mt. Mantell, 1700 m., *type collection,* G.H.C.

Distribution: Endemic.

Two of the hosts are endemic, the third, *C. pyreniaca,* being of world-wide distribution (Cheesem. 1925, p. 254-269).

No less than four species of the genus *Puccinia* are now known to occur on *Carex* in New Zealand. They may be separated by the following key:—

Uredospore germ pores equatorial.
  Teleutospore apex sharply acuminate .. . .. *P. rautahi*
  Teleutospore apex rounded.
    Uredospore epispore 1.5 microns thick; germ pores 4 .... *P. Caricis*
    Uredospore epispore 2.5-3 microns thick; germ pores 2 ... . . , *P. mania*
Uredospore germ pores superequatorial .... *P. maurea*

This species differs from *P. Caricis* in the longer, narrower, more deeply coloured teleutospores, with their peculiar, prominent, obliquely placed germ pores penetrating the thickened apices. In the uredostage it may be distinguished by the two conspicuous germ pores and thick epispore.

4. **Puccinia rautahi** n. sp. Fig. 6.

O. Unknown.

II. Uredosori amphigenous, scattered, orbicular or elliptical, 0.2-1 mm. diameter, chestnut brown, partially covered by the ruptured

FIG. 3. FIG. 4.

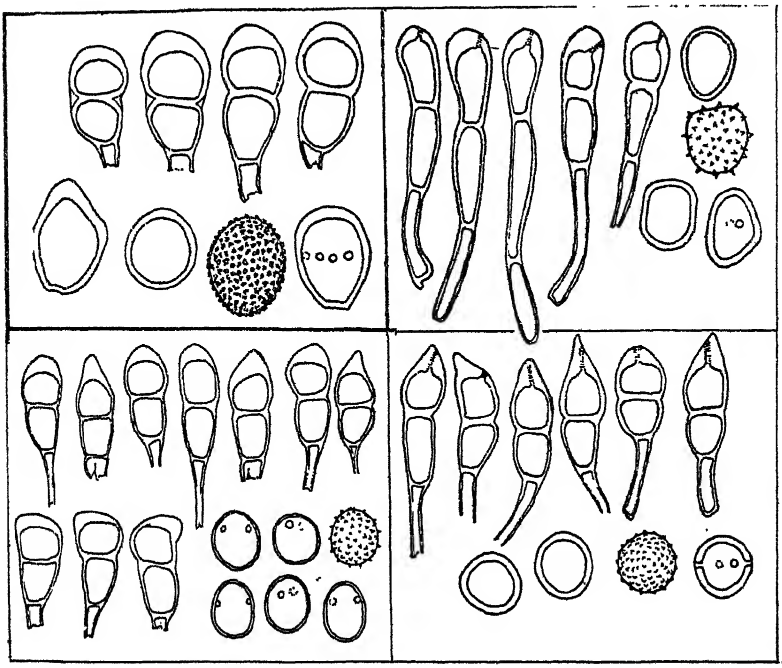


FIG. 5. FIG. 6.

FIG. 3.—*Puccinia Schoenus* on *Schoenus pauciflorus;* uredospores and teleutospores.
FIG. 4.—*P. mania* on *Carex wakatipu;* uredospores and teleutospores.
FIG. 5.—*P. maurea* on *Carex inversa;* uredospores and teleutospores. Note the super-equatorial germ pores of the uredospores.
FIG. 6.—*P. rautahi* on *Carex Gaudichaudiana;* uredospores and teleutospores. All × 340.

epidermis. Spores elliptical, subglobose or irregularly polygonal, 24-30 x 20-24 microns, average 27 x 21 microns; epispore pallid chestnut brown, 3-3.5 microns thick, sparsely and moderately echinulate; germ pores 3-4, equatorial.

III. Teleutosori chiefly hypophyllous, orbicular or elliptical, 0.2-1 mm. diameter, scattered, not aggregated into lines, dark brown, naked. Spores subclavate, 36-48 x 18-22 microns, average 42 x 20 microns; apex sharply acuminate, thickened to 14 microns, often prolonged into a beak-like process, concolorous with the spore, basal cell cuneiform, narrower and sometimes longer than the upper; constricted at the septum; epispore smooth, chestnut brown, 3 microns thick in the upper cell, 2-2.5 microns in the lower; pedicel coloured, continuous with the spore, persistent, to 50 x 6 microns; germ pore of the upper cell apical, basal pore immediately beneath the septum.

X. Mesospores uncommon, elliptical.

Hosts: *Carex Gaudichaudiana* (Booth) Kunth. Otago: Mt. Judah, 900 m., *type collection*, W. D. Reid; Glenorchy, 370 m. Southland: Longwood Range, 500 m.

Carex Kirkii Petrie. Otago: Macraes, 600 m.

Distribution: Endemic.

The former host is indigenous and extends to Australia; the latter is endemic and is confined to the South Island (Cheesem. 1925, pp. 256-263).

The orbicular sori, strongly acuminate, often beaked, thick-walled teleutospores, thick-walled uredospores with their 3-4 equatorial germ pores are the characters of the species.

5. **Puccinia maurea** n. sp. Fig. 5.

O. Unknown.

II. Uredosori amphigenous, chiefly hypophyllous, scattered, not arranged in lines, ferruginous, elliptical, 0.1-2 mm. diameter, partially covered by the ruptured epidermis. Spores obovate or shortly elliptical, often somewhat angular, 24-32 x 20-28 microns, average 29 x 22 microns; epispore chestnut brown, 1.5-2 microns thick, sparsely and moderately echinulate; germ pores 2 (rarely 3), super-equatorial; immixed with numerous hyaline, cylindrical paraphyses.

III. Teleutosori hypophyllous, scattered, orbicular, or elliptical, 0.2-0.5 mm. diameter, dark brown, partially covered by the ruptured epidermis. Spores subclavate or elliptical, 32-44 x 16-22 microns, average 41 x 19 microns; apex bluntly acuminate, thickened to 8 microns, darker in colour, basal cell slightly shorter and narrower; slightly constricted at the septum; epispore chestnut brown, 1.5 microns thick, smooth; pedicel persistent, tinted, to 24 x 8 microns; germ pore of the upper cell apical, basal pore immediately beneath the septum; immixed with numerous cylindrical hyaline paraphyses.

X. Mesospores numerous, elliptical.

Hosts: *Carex inversa* R. Br. Auckland: Penrose, 100 m.; Mt. St. John, 300 m., *type collection*, D. Petrie. Otago: Jacksons, 270 m.

Carex pumila Thunb. Wellington: Seatoun, coast; Plimmerton, coast.

Carex Wallii Petrie. Southland: Centre Hill, below Lumsden.
Distribution: Endemic.

One host, *C. Wallii*, is endemic and confined to one locality in the South Island; the other two are indigenous, *C. inversa* extending to Australia, *C. pumila* to Australia, Asia and South America. (Cheesem., 1925, pp. 255, 260, 277).

The characters of the species are the small, acuminate, thin-walled teleutospores, and the thin-walled uredospores with their 2, conspicuous super-equatorial germ pores.

6. **Puccinia Schoenus** n. sp. Fig. 3.

Uredo Schoenus G. H. Cunn., *Trans. N.Z. Inst.*, vol. 59, p. 499, 1928.

O. Unknown.

II. Uredosori scattered, seldom confluent, seated on discoloured reddish spots, elliptical, 1-2 mm. long, erumpent, bullate, ferruginous, long covered. Spores obovate or elliptical, 32-48 x 24-32 microns, average 40 x 30 microns; epispore pallid fuscous or yellowish brown, 3 microns thick, thickened apically to 6-8 microns and darker in colour, somewhat closely covered with coarse, areolate warts; germ pores 5-6, equatorial.

III. Teleutosori similar to the uredosori. Spores subclavate, 36-56 x 24-30 microns, average 44 x 27 microns; apex rounded, thickened to 8 microns, basal cell somewhat attenuate, both about the same size, or the lower slightly narrower; slightly constricted at the septum; epispore dark chestnut brown, smooth, 2 microns thick in the upper cell, 1.5 microns in the lower; pedicel persistent, coloured, to 20 x 10 microns; germ pore of the upper cell apical, basal pore immediately beneath the septum.

X. Mesospores rare, elliptical or obovate.

Host: *Schoenus pauciflorus* Hook. f. Canterbury: Cook Range, 700 m., *type collection*, G.H.C.

Distribution: Endemic.

The host is endemic and common throughout (Cheesem., 1925, p. 229).

This was previously described as an *Uredo*, but extended examination has revealed the presence of a few teleutospores associated with the uredospores.

7. **Puccinia tenuispora** McAlpine.

In a former paper (1923, p. 653) I recorded this species as *P. obscura* Schroet.; but critical comparison of our material with authentic American and European specimens shows it to differ in several particulars, especially in the shorter, broader, thinner-walled teleutospores, and the equatorial (not super-equatorial as in *P. obscura*) germ pores of the uredospores. Comparison with type material of *P. tenuispora* shows it most closely resembles this species, differing only in the shorter and broader teleutospores. This is strengthened by the fact that although aecidia of *P. obscura* occur on *Bellis*

perennis (being an heteroecious species) this stage has not been collected in New Zealand or Australia, the aecidium on this host in New Zealand belonging to the autoecious species *P. distincta.*

8. **Puccinia toa** nov. nom.

Puccinia Halorrhagidis G. H. Cunn., *Trans. N.Z. Inst.*, vol. 54, p. 664, 1923.

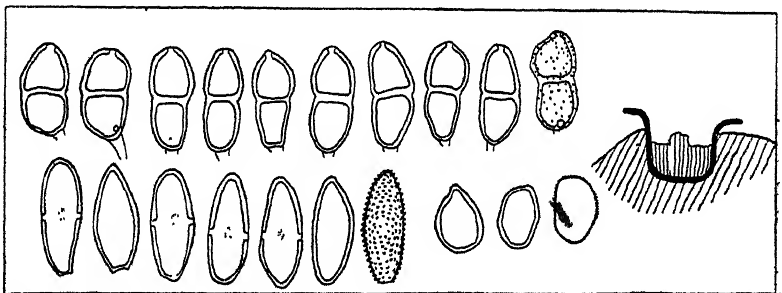
As *P. Halorrhagidis* is preoccupied, being applied to a different species in 1913 by Sydow, the name has been changed as above.

9. **Puccinia koherika** n. sp. Fig. 7.

O. Pycnia sparse, scattered, immersed, associated with the aecidia.

I. Aecidia on leaves, crowded in small groups on inflated spots, on stems forming inflated areas up to 25 mm. long, orange. Peridia erumpent, cupulate, 0.5-0.7 mm. diameter, margins recurved, lacerate, toothed, tinted. Spores elliptical, subglobose or polygonal, 22-30 x 16-21 microns, average 26 x 20 microns; epispore hyaline, 1 micron thick, finely and densely verruculose.

Fig. 7.



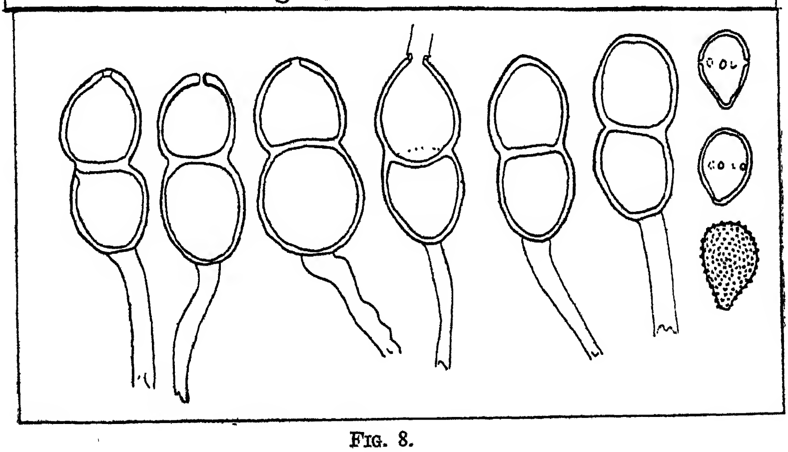


Fig. 8.

Fig. 7.—*P. koherika* on *Angelica rosaefolia;* aecidium, aecidiospores, uredospores and teleutospores.

Fig. 8.—*P. Moschata* on *Olearia moschata;* uredospores and teleutospores. Aecidium × 25, spores × 340.

II. Uredosori hypophyllous, scattered, orbicular, 0.5-1 mm. diameter, ferruginous, pulverulent, partly covered by the ruptured epidermis. Spores fusoid or elongate-elliptical, 38-53 x 16-20 microns, average 43 x 18 microns; epispore pallid brown, 1.5 microns thick, densely covered with coarse, hyaline verrucae; germ pores 3-4, equatorial; immixed with a few hyaline paraphyses.

III. Teleutosori similar to the uredosori but dark brown. Spores elliptic-oblong, less commonly subclavate, 36-48 x 16-22 microns, average 40 x 19 microns; apex rounded, seldom bluntly acuminate, not thickened, base subattenuate, both cells about the same size and colour; slightly constricted at the septum; epispore minutely verruculose, 1.5-2 microns thick, chestnut brown; pedicel deciduous, hyaline, fragile, to 50 x 6 microns; germ pore of the upper cell apical, basal pore from two-thirds to three-quarters below the septum.

Host: *Angelica rosaefolia* Hook. f. Auckland: Tolago Bay, 20 m., *type collection,* H. H. Allan, J. G. Gibbs. Hawkes Bay: Nuhaka, 120 m.

Distribution: Endemic.

The host is an endemic species now known to occur only in the North Island (Cheesem., 1925, p. 684).

The rust is separated from others on the Umbelliferae by the minutely verruculose epispore of the teleutospores, and by the elongate-elliptic shape of the uredospores, and their blunt verrucae covering the epispore.

10. **Puccinia pseudomenthae** n. sp. Fig. 9.

O. Pycnia amphigenous, in small groups, honey coloured.

I. Aecidia amphigenous, chiefly hypophyllous, and on stems, scattered evenly over the surface. Peridia cupulate, 0.25-0.5 mm. diameter, margins white, somewhat incurved, lacerate. Spores subglobose, 18-22 x 14-20 microns, average 20 x 17 microns; epispore hyaline, 1 micron thick, densely and somewhat coarsely verruculose.

II. Uredosori hypophyllous, on yellow spots, scattered, orbicular, minute, 0.25-0.5 mm. diameter, cinnamon brown, pulverulent, surrounded by the ruptured epidermis. Spores subglobose or obovate, 18-24 x 14-20 microns, average 21 x 16 microns; epispore sparsely and coarsely echinulate, pallid brown, 1.5 microns thick; germ pores 3, equatorial; immixed with numerous hyaline, cylindrical paraphyses.

III. Teleutosori hypophyllous, scattered, minute, to 0.5 mm. diameter, chocolate brown, pulverulent, surrounded by the ruptured epidermis. Spores broadly elliptical 22-30 x 17-24 microns, average 27 x 19 microns; apex rounded, not thickened, base rounded, both cells the same size and colour; slightly or not constricted at the septum; epispore somewhat sparsely warted, 1.5 microns thick, pallid chestnut brown; pedicel persistent, hyaline, fragile, to 40 x 5 microns; germ pore of the upper cell apical, basal pore varying in position between the septum and pedicel, both papillate.

Host: *Mentha Cunninghamii* Benth. Canterbury; Raikaia Gorge, 400 m. Westland: Franz Josef Glacier, 250 m., *type collection,* H. H. Allan, G.H.C.; Fox Glacier, 250 m. Otago: Table Bay, Wakatipu, 835 m.; Dunstan Mts., 720 m.

Distribution: Endemic.

The host is endemic and common throughout (Cheesem., 1925, p. 766).

In a former paper (1923, p. 672) this rust was described as *P. Menthae* Pers. At that time no aecidia had been collected, the description given being drawn from European material. Since this paper appeared numerous additional collections have been made, and

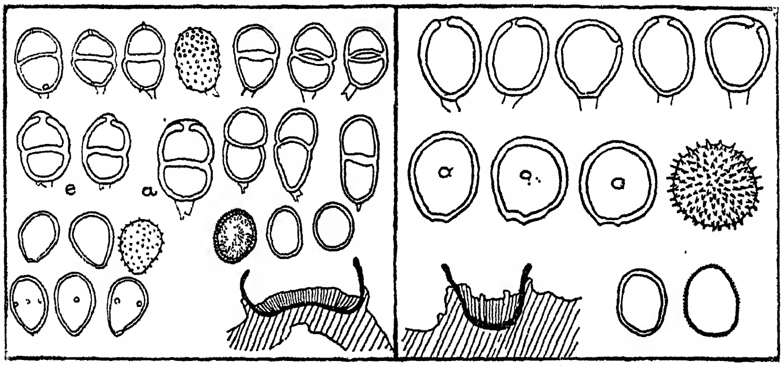


FIG. 9. FIG. 10.

FIG. 9.—*P. pseudomenthae* on *Mentha Cunninghamii;* aecidium, aecidiospores uredospores and teleutospores. The teleutospores marked *e* are of *P. Menthae* from European material, that marked *a* is from American material.

FIG. 10.—*Uromyces Sellieriae* on *Selliera radicans;* aecidium, aecidiospores, uredospores and teleutospores. Aecidia $\times$ 25, spores $\times$ 340.

examination of these shows that our species differs considerably. The scattered aecidia, small size of the aecidiospores (averaging 20 x 17 microns as against an average of 33 x 25 microns in British material); thinner epispore and smaller size of the uredospores; smaller, more fragile teleutospores (27 x 19 microns as against 33 x 24 microns in European specimens of *P. Menthae*), with their much thinner, more coarsely warted, non-capped epispore, are characters separating it from European or North American specimens of *P. Menthae.*

11. **Puccinia Moschata** n. sp. Fig. 8.

Uredo Moschatus G. H. Cunn., *Trans. N.Z. Inst.,* vol. 59, p. 499, 1928.

O.I. Unknown.

II. Uredosori hypophyllous, scattered, orbicular, 0.5-1 mm. diameter, pulverulent, pallid lemon yellow, deeply immersed in the tomentum of the leaf. Spores subglobose or obovate, 24-40 x 20-24 microns, average 32 x 21 microns; epispore hyaline, 1 micron thick, finely and closely covered with small, round-topped, deciduous verrucae; germ pores 4-6, equatorial; immixed with numerous, cylindrical, hyaline paraphyses.

III. Teleutosori similar to and associated with the uredosori. Spores elliptic-oblong, 64-72 x 34-40 microns, average 69 x 32 microns; apex rounded, not thickened, base rounded, both cells about the same

size, or the lower sometimes inflated; constricted at the septum; epispore hyaline, smooth, 1.5 microns thick; pedicel persistent, hyaline, to 100 x 10 microns; germ pore of the upper cell apical, basal pore immediately beneath the septum.

Host: *Olearia moschata* Hook. f. Canterbury: Black Birch Creek, Mt. Cook, 1200 m., *type collection*, G.H.C.

Distribution: Endemic.

The host is endemic and confined to the South Island (Cheesem., 1925, p. 923).

The characters of this species, separating it from others on *Senecio* and *Olearia*, are the presence of uredospores, with their thin, hyaline epispores, covered with deciduous verrucae, and their numerous germ pores; thin, almost hyaline epispores of the teleutospores. The latter resemble those of *P. akiraho* in shape, but differ in the much smaller size.

12. **Puccinia akiraho** nov. nom.

Puccinia novae-zelandiae G. H. Cunn., *Trans. N.Z. Inst.*, vol. 54, p. 686, 1923.

The name formerly used for this section is too close to *P. novo-zelandica* Bubak (1901), and so has been changed as above.

13. **Puccinia aorangi** n. sp. Fig. 11.

O. Unknown.

III. Teleutosori hypophyllous, densely aggregated into groups extending over the greater portion of the leaf, which is yellowed above in consequence, elliptic or orbicular, to 1.5 mm. diameter, pulverulent, dark chocolate brown, naked, covered with the tomentum of the leaf. Spores subclavate, 55-76 x 20-25 microns, average 60 x 24 microns; apex bluntly acuminate or rounded, thickened to 10 microns, base attenuate, lower cell longer and narrower, usually cuneiform; slightly constricted at the septum; epispore chestnut brown, smooth, 2 microns thick in the upper cell, 1.5 microns in the lower; pedicel

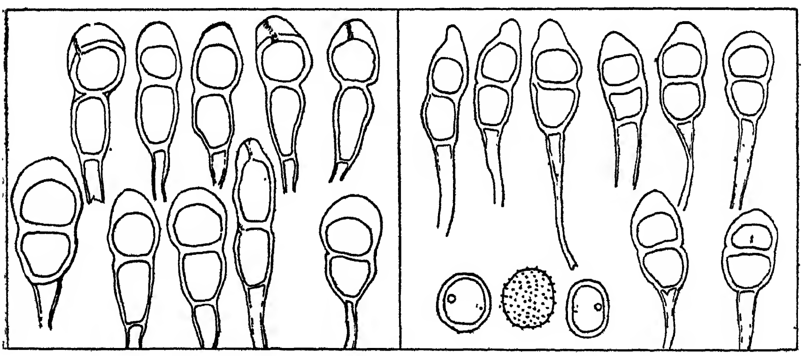


FIG. 11. FIG. 12.

FIG. 11.—*Puccinia aorangi* on *Celmisia major;* teleutospores × 340.
FIG. 12.—*P. gnaphaliicola* on *Gnaphalium* hybrid; uredospores and teleutospores, × 340.

persistent, hyaline, tapering, to 25 x 10 microns; germ pore of the upper cell apical or slightly obliquely placed, basal pore immediately beneath the septum.

X. Mesospores common, elliptic or fusoid.

Host: *Celmisia major* Cheesem. Taranaki: Mt. Egmont, 1600-2000 m., *type collection,* H. H. Allan, G.H.C.

Distribution: Endemic.

The host is endemic, with a somewhat limited distribution in the North Island (Cheesem., 1925, p. 952).

The rust differs from the three other species of *Puccinia* occurring on *Celmisia* in that apparently only teleutospores occur in the cycle. From *P. fodiens* it is separated by the smooth epispore; from *P. Celmisiae* by the thickened apex of the spore; and from *P. egmontensis* by the prominent sori, broader spores and stouter pedicels.

14. **Puccinia gnaphaliicola** P. Hennings. Fig. 12.

P. Henn., *Hedwigia Beibl.*, vol. 38, p. 68, 1899.

Uredo Gnaphalii Speg., *Anal. Soc. Ci. Argent.*, vol. 12, p. 73, 1881.

Puccinia Gnaphalii (Speg.) P. Henn., *Hedwigia Beibl.*, vol. 41, p. 66, 1902.

P. Gnaphalii Speg., *Anal. Mus. Nac. Buenos Aires,* vol. 19, p. 309, 1909.

O. Unknown.

II. Uredosori amphigenous, chiefly hypophyllous, scattered, ferruginous, orbicular or elliptical, to 2 mm. diameter, pulvinate, pulverulent, partly covered by the tomentum of the leaf. Spores globose or subglobose, 22-27 x 21-27 microns, average 25 x 24 microns; epispore ferruginous, 2.5-3 microns thick, thickened more above the hilum, moderately and finely echinulate, spines tending to disappear when spores mature; germ pores 2 (rarely 3), equatorial.

III. Teleutosori similar to the uredosori but chocolate brown and compact. Spores elliptical, fusoid or subclavate, 38-56 x 18-24 microns, average 45 x 21 microns; apex bluntly acuminate, thickened to 12 microns, base subattenuate, lower cell longer and narrower; slightly constricted at the septum; epispore smooth, chestnut brown, 2 microns thick in the upper cell, 1.5 microns in the lower; pedicel tinted beneath the spore, hyaline, persistent, to 50 x 8 microns; germ pore of the upper cell apical, basal pore immediately beneath the septum.

X. Mesospores rare, elliptical.

Host: *Gnaphalium luteo-album* × *G. purpureum,* Auckland: Tokaanou Hautu Prison Farm, 300 m., H. H. Allan.

Type locality: Brazil, Rio de Janeiro, on leaves of *Gnaphalium* sp.

Distribution: North and South America; New Zealand.

Dr. Allan informs me that the host is a hybrid between the indigenous *G. luteo-album* and the introduced *G. purpureum.*

Comparison of this collection with herbarium material from North America, shows it to be *P. gnaphaliicola.*

The species is usually cited as *P. Gnaphalii,* but this is not in

accordance with the International Rules of Botanical Nomenclature, which require that the name first applied to the perfect form shall be used.

15. **Uromyces Sellieriae** n. sp. Fig. 10.

O. Unknown.

I. Aecidia amphigenous, scattered, erumpent, orange. Peridia cupulate, margins hyaline, erect, dentate. Spores elliptical, occasionally polygonal, 26-36 x 18-24 microns, average 30 x 21 microns; epispore hyaline, finely and densely verruculose, 1 micron thick.

II. Uredosori amphigenous, scattered, irregular, frequently elliptical, to 3 mm. long, bullate, pulverulent, cinnamon brown, partially covered by the epidermis. Spores subglobose or flattened globose, 28-35 x 30-36 microns, average 33 x 34 microns; epispore sparsely aculeate, 1.5-2 microns thick, pallid brown; germ pores 2, equatorial.

III. Teleutosori immixed with and indistinguishable from the uredosori. Spores elliptical, obovate, often pyriform, 28-35 x 18-28 microns, average 30 x 27 microns; apex bluntly rounded, not thickened, base subattenuate; epispore smooth, 1.5-2 microns thick, chestnut brown; pedicel persistent, hyaline, to 45 x 8 microns; germ pore apical.

Host: *Selliera radicans* Cav. Wellington: Evans Bay, 5 m.; *type collection,* E. H. Atkinson; Castle Point, coast. Canterbury: Ashburton, 30 m. Otago: Dunstan Mts., 450 m.

Distribution: Endemic.

The host is indigenous and widespread, and occurs also in Australia, Tasmania and Chile (Cheesem., 1925, p. 894).

This species was in a former paper (1923, p. 635) referred to *Uromyces puccinioides;* but the non-thickened apex and smaller size of the teleutospores, smaller aecidiospores and presence of uredospores in the cycle show it to be distinct.

16. **Uromyces Scaevolae** nov. nom.

Uromyces puccinioides Berk. et F. v. M., *Journ. Linn. Soc.,* vol. 13, p. 173, 1872.

As the specific name is preoccupied, being used in 1851 by Rabenhorst for a different species, I have renamed this species as above.

17. **Aecidium Ranunculi-insignis** n.f. sp. Fig. 14.

O. Pycnia chiefly epiphyllous, in small crowded groups in the region of the aecidia.

I. Aecidia chiefly hypophyllous, and on petioles and stems, crowded in elliptical groups, seated on slightly inflated areas, slightly erumpent. Peridia 0.6-0.7 mm. diameter, margins scarcely erumpent, toothed, white; peridial cells to 40 x 35 microns, lozenge shaped, walls 4 microns thick, equal, verrucose. Spores subglobose or polygonal, 25-32 x 20-25 microns, average 28 x 23 microns; epispore hyaline, 2 microns thick, finely and densely tuberculate-areolate, appearing reticulate.

Hosts: *Ranunculus geraniifoliis* Hook. f. Wellington: Mt. Hector, 1300-1700 m. Nelson: Mt. St. Arnaud, 1800 m. Canterbury: Cass, 1000 m.

Ranunculus insignis Hook. f. Taranaki: Mt. Egmont, 1200 m., *type collection*, H. H. Allan. Wellington: Mt. Dennan, 1500 m.; Mt. Hector, 1700 m.

Ranunculus nivicola Hook. Taranaki: Mt. Egmont, 1100-1500 m.

Ranunculus pachyrrhizus Hook. f. Otago: Lake Harris, 1200 m.

Distribution: Endemic.

FIG. 13. FIG. 14.

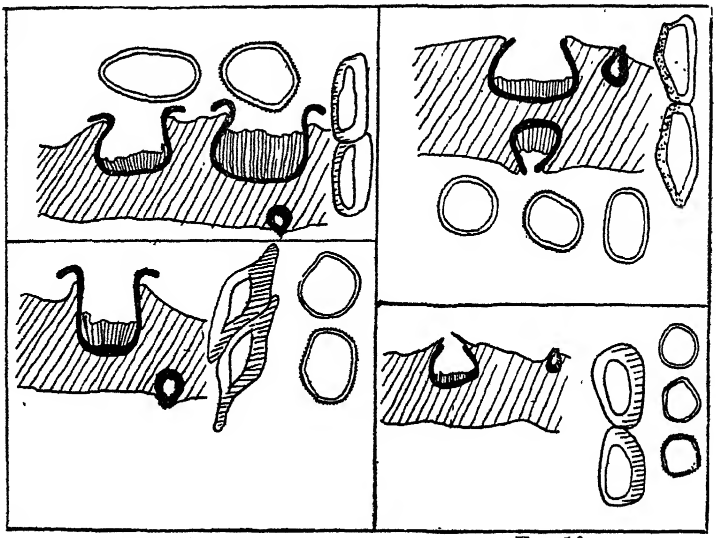


FIG. 15. FIG. 16.

FIG. 13.—*Aecidium Ranunculi-Lyallii* on *Ranunculus Lyallii;* aecidia, pycnium, aecidiospores and peridial cells.

FIG. 14.—*A. Ranunculi-insignis* on *R. insignis;* aecidia, pycnium, aecidiospores and peridial cells.

FIG 15.—*A. Ranunculi-Monroi* on *R. Monroi* aecidium, pycnium, aecidiospores and peridial cells.

FIG. 16.—*A. Ranunculi-depressus* on *R. depressus;* aecidium, pycnium, aecidiospores and peridial cells.

Aecidia and pycnia × 25, spores and cells × 340.

All hosts are endemic, *R. pachyrrhizus* being confined to the South Island (Cheesem., 1925, pp. 438, 451).

The characters of the species are the areolate spores, verrucose peridial cells, and the scarcely crumpent peridia.

Critical examination of the numerous collections of aecidia on species of *Ranunculus* has shown there are several species present in New Zealand (most of which were in a former paper grouped under the aggregate species *A. Ranunculacearum*: 1924, p. 34), which may be separated by the following key:—

Peridial cells tuberculate or verrucose, not sculptured .... *A. Ranunculi-insignis*

Peridial cells sculptured.	
Peridial cells lozenge shaped, with acuminate apices	*A. Ranunculi-Monroi*
Peridial cells elliptical or oblong, with rounded or truncate apices.	
Spores averaging 37 x 25 microns .	*A. Ranunculi-Lyallii*
Spores averaging 20 x 16 microns . .	*A. Ranunculi-depressus*

18. **Aecidium Ranunculi-Monroi** n.f. sp. Fig. 15.

O. Pycnia amphigenous, chiefly epiphyllous, in small scattered groups associated with the aecidia.

I. Aecidia amphigenous, chiefly hypophyllous, crowded in bright orange groups seated on slightly inflated areas. Peridia cupulate, 0.6 mm. diameter, margins reflexed, toothed, white; peridial cells slipper-shaped, apex acuminate, base truncate, to 48 x 32 microns, wall thickened considerably at apex and base, to 8 microns in the centre, strongly sculptured. Spores elliptical, obovate, polygonal or subglobose, 26-35 x 19-25 microns, average 29 x 21 microns; epispore hyaline, 1 micron thick, finely and densely covered with rounded verrucae.

Host: *Ranunculus Monroi* Hook. f. Nelson: Mt. Arthur, 1300-1900 m. Canterbury: Mt. Hutt, 1200 m. Westland: Mt. Trovatore, 1600-1700 m., *type collection,* G.H.C.

Distribution: Endemic.

The host is endemic and has a limited distribution in the mountains of both Islands (Cheesem., 1925, p. 439).

The rust is characterized by the verrucose epispore, large size of the aecidiospores, reflexed aecidia, and slipper-shaped, thick-walled peridial cells.

19. **Aecidium Ranunculi-Lyallii** n.f. sp. Fig. 13.

O. Pycnia in sparse epiphyllous groups, seated above the aecidia, almost black.

I. Aecidia amphigenous, chiefly hypophyllous, aggregated into dense orange groups on slightly inflated areas. Peridia to 0.8 mm. diameter, margins revolute, white, lacerate; peridial cells oblong, ends square, to 50 x 30 microns, 4-5 microns thick on the inner side, to 8 microns on the outer, strongly sculptured. Spores elliptical, subglobose or polygonal, irregular, 32-45 x 20-28 microns, average 37 x 25 microns; epispore hyaline, 2 microns thick, finely and densely verruculose-areolate, appearing reticulate.

Host: *Ranunculus Lyallii* Hook. f. Canterbury: Waimakiriri Glacier, 700 m.; Cook Ranges, 700 m.; Kea Point, Mt. Cook, 700 m., *type collection,* H. H. Allan-G.H.C.; Black Birch Creek, 900 m.; Tasman Moraine, 900 m.; McKinnon's Pass, 600 m.; Arthur's Pass, 700-900 m.; Sugar Loaf, Cass, 700 m. Westland: Mt. Trovatore, 1300 m.; Mt. Rangitaipo, 1200-1700 m.; Alec's Knob, Franz Josef Glacier, 1100 m.

Distribution: Endemic.

The host is endemic and confined to the South Island (Cheesem., 1925, p. 436).

The rust is characterized by the oblong, sculptured cells of the peridium, dense groups of aecidia, and large size and areolate epispore of the aecidiospores. It is exceedingly abundant on this host wherever encountered.

20. **Aecidium Ranunculi-depressus** n.f. sp. Fig. 16.

O. Pycnia in small scattered groups associated with the acedia.

I. Aecidia hypophyllous, in small scattered groups. Peridia depressed globose, margins alone showing; peridial cells elliptical, walls thickened to 10 microns, strongly sculptured. Spores subglobose or polygonal, 18-22 x 14-18 microns, average 20 x 16 microns; epispore hyaline, 1 micron thick, finely and densely covered with rounded verrucae.

Host: *Ranunculus depressus* Kirk. Otago: Mt. Genivere, 1000 m., *type collection*, W. D. Reid.

Distribution: Endemic.

The host is endemic and confined to the South Island (Cheesem., 1925, p. 450).

The elliptical, sculptured, peridial cells, and especially the small spores, are the characters of the species.

All four forms have been compared with the aecidial stages of *Puccinia contegens*, *P. Foyana* and *Uromyces Dactylidis*, and found to be distinct. Thus the aecidium on *Ranunculus repens* has been proved by the aid of cultures to belong to the cycle of *Uromyces Dactylidis;* that on *Ranunculus lappaceus* and *R. multiscapus* to *Puccinia contegens;* and that on *Ranuculus Enysii* to *Puccinia Foyana.*

21. **Caeoma kaiku** n.f. sp. Fig. 17.

O. Unknown.

I. Caeomata in irregular circular groups of 3-7, or scattered and hypophyllous, 1-3 mm. diameter, orbicular, pulvinate, orange. Caeomospores commonly obovate, often elliptical or polygonal, 25-33 x 20-24 microns, average 28 x 21 microns; epispore hyaline, 2-2.5 microns thick, covered with coarse, round-topped deciduous tubercules, appearing areolate.

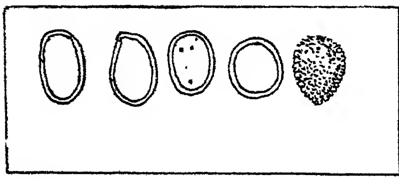


FIG. 17.

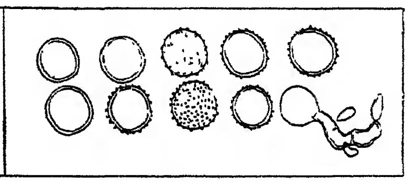


FIG. 18.

FIG. 17.—*Caeoma kaiku* on *Parsonsia* hybrid; caeomospores × 340.

FIG. 18.—*Ustilago Asprellae* on *Asprella gracilis;* spores × 500. Germinating spore on the right.

Host: *Parsonsia capsularis* × *P. heterophylla.* Wellington: Waimarino, 460 m., *type collection,* J. C. Neill.

Distribution: Endemic.

Dr. H. H. Allan has identified the host as a hybrid between *Parsonsia capsularis* and *P. heterophylla.*

The rust differs from *Aecidium Parsonsiae* Petch in the absence of a peridium, larger spores, and much thicker epispore. The spore markings, too, are characteristic.

22. **Uredo Salicorniae** n.f. sp.

Uredosori amphigenous and on stems and bracts, scattered, bullate, 0.2-0.6 mm. diameter, ferruginous, pulverulent, partially covered by the ruptured epidermis. Spores elliptical, obovate or subglobose, 26-32 x 24-28 microns, average 29 x 25 microns; epispore chestnut brown, 2 microns thick, finely and closely echinulate; immixed with numerous, hyaline, cylindrical paraphyses.

Host: *Salicornia australis* Sol. ex Forst. f. Canterbury: Lake Ellesmere, coast; *type collection,* H. H. Allan.

Distribution: Endemic.

The host is an endemic species, not uncommon on the coast throughout (Cheesem., 1925, p. 410).

This may be the uredostage of *Uromyces Salicorniae* de Bary, the only rust recorded on this host genus, but as only uredospores are present on the specimens, and as these do not altogether agree with the published descriptions of this species, our form has been provisionally named as new.

USTILAGINALES.

23. **Ustilago Asprellae** n. sp. Fig. 18.

Sori destroying the infloresences, enclosed in a lead-coloured membrane, when semi-compact, ultimately becoming exposed when black and pulverulent, finally dissipating leaving the bare rachis of the infloresence.

Spores globose or subglobose, 9-11 microns in diameter; epispore ferruginous, 0.75-1 micron thick, covered with coarse, irregular tubercules, which are variable in size and shape.

Host: *Asprella gracilis* (Hook. f.) Kirk. Nelson: Korere, 500 m., *type collection,* H. H. Allan.

Distribution: Endemic.

The host is an endemic species not uncommon throughout both Islands (Cheesem., 1925, p. 211).

This smut is close to *Ustilago bullata* on *Agropyron scabrum* (Lab.) Beauv. but differs in the spore markings, which are larger, coarser and more irregular.

List of Species Recorded: Synonyms in Italics.

List of Hosts Recorded.

Literature Cited.

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Cunningham, G. H., 1923. The Uredinales, or Rust Fungi, of New Zealand, Part 1., *Trans. N.Z. Inst.*, vol. 54, pp. 619-704.

—— 1924. The Uredinales, or Rust Fungi, of New Zealand. Supplement to Part 1 and Part 2, *Trans. N.Z. Inst.*, vol. 55, pp. 1-58.

The Lepidoptera of Mount Cook District, with Descriptions of New Species.

By ALFRED PHILPOTT, Hon. Entomologist, Auckland Museum.

[*Read before the Auckland Institute, 25th February, 1930; received by Editor, 4th March, 1930; issued separately, 23rd August, 1930.*]

HISTORICAL.

THE first lepidopterist to collect in the neighbourhood of Mount Cook was Mr. R. W. Fereday, who visited the locality in February, 1888. There is no record of the time spent in the district, but as a result of Mr. Fereday's work six new species were described by Mr. E. Meyrick in the *Transactions of the Entomological Society of London* for 1901. Early in December 1899, Mr. G. V. Hudson stayed at the old "Hermitage" for five days. Inclement weather interfered with the full success of the trip, but Mr. Hudson formed a high opinion of the entomological possibilities of the region, an account of which he gave in his presidential address to the Wellington Philosophical Society (1900).

In 1909 (?) Mr. T. Hall collected coleoptera in the neighbourhood and while so engaged captured a specimen, now in the Auckland Museum, of *Dasyuris austrina* Philp. About the middle of March, 1923, Dr. R. J. Tillyard stayed for a day or two at the "Hermitage" and, though not giving special attention to the lepidoptera, succeeded in capturing a new species of *Simaethis*—subsequently named after him by the writer—and a good series of the rather local butterfly, *Erebia butleri* Fered.

With Mr. and Mrs. Stewart Lindsay, the writer spent from 28th December, 1928, to 7th January, 1929, in camp near the "Hermitage." The weather was rather broken but large collections were made. Returning alone on the 7th of the following February, he made a stay of 13 days, during which period no rain fell though collecting was somewhat interfered with on several days by strong winds. Finally, a visit was made in the early part of December, 1929, the period covering from the 6th to the 17th. The weather, for the most part, was cold and wet and more than half of the time was spent in enforced idleness.

The expenses of the last two visits to the locality were defrayed by a Research Grant from the N.Z. Institute, for which assistance the writer tenders his grateful thanks.

In accordance with the conditions covering the grant, the material collected has been equally divided between the Canterbury Museum, the Dominion Museum and the Cawthron Institute.*

*It is fitting that a note of appreciation of the generosity of the Curator (Professor R. Speight) of the Canterbury Museum should here be recorded. The Research Grant regulations provide that all specimens obtained by the aid of a grant shall become the property of a Museum or University College within the province where the collections are made. By waiving his rights in the matter Professor Speight has enabled two other institutions to become possessed of a fairly extensive and representative collection of the Lepidoptera of Mount Cook.

Notes on the Collecting Localities.

Speaking generally, daylight collecting of lepidoptera in the Mount Cook district does not yield abundant results. There is a rather poor representation of those families—such as the Gelechiidae and Glyphipterygidae—which are attached to open country and lowly herbage, and as there is a very large proportion of this class of country in the neighbourhood of Mount Cook the effect is marked. Probably the general high elevation (the "Hermitage" is situated at 2,500 ft.) and the amount of snowfall militates against those species which have their habitat under the conditions just mentioned; the annual melting of the snow, with its accompaniments of excessive moisture and damage to vegetation, could hardly have any other effect. But the comparative poorness of the day collecting is amply made up for by the abundance of species to be obtained after dark, either by means of netting by lamplight, collecting from certain blossoms or by the attraction of sugared bait.

A detailed description of the chief localities follows.

Governor's Bush.—This is the only piece of bush of any extent in the district. It clothes the spur which runs down to the Black Birch Stream and a few hundred yards before the "Hermitage" is reached a fine track winds up this spur and crosses it to run down to the Baby Glacier Valley, where a crossing can be made for the ascent of Sebastopol Spur. The chief forest tree on the lower part of the track is *Nothofagus Menziesii*, but this gives place to *Phyllocladus alpinus* and *Podocarpus Halli* towards the top of the spur. Here the bush is of lower growth, so that at several points there is an almost unobstructed view of the valley opposite. This upper part of the track is especially favourable to collecting by sugared bait, the contrast between the few specimens attracted in the beech forest and the abundant attendance in the upper stretch being most marked. Just before the track reaches the Black Birch Stream there is a grove of *Hoheria glabrata* which, when in flower (in February), attracts moths in great numbers. On the whole, the neighbourhood of this *glabrata* grove affords the best bush-collecting to be had, there being here a greater variety of vegetation than elsewhere.

If, instead of taking the bush track, the base of the spur is followed round towards the mouth of the Black Birch Stream gorge, a very favourable spot for collecting will be found. In a sheltered corner, just before the stream is reached, there is a small area of flat ground covered with more or less open forest. The chief trees are *Podocarpus Halli, Phyllocladus alpinus* and *Griselinia littoralis*, the more shrubby species being *Coprosma* spp. and *Hoheria glabrata*. A very robust growth of the fern, *Polystichum vestitum*, borders the base of the hill and extends to all the more shaded parts. In this restricted spot lepidoptera are abundant and both day and evening collecting prove satisfactory. The usually rather rare *Chloroclystis punicea* was abundant here at the flowers of a species of *Hebe*.

Governor's Bush extends along the lower slope of the mountain behind the "Hermitage" and here another track, the Glencoe Walk, provides access to the forest. Along the base of the hill between these two tracks are several more or less open glades, which form

convenient beats for the collector. Not far beyond the "Hermitage" the heavily timbered forest gives place to a more scrubby growth and this, as it extends out into the valley, becomes mixed with a large proportion of *Discaria* (Wild Irishman), forming a rather unfavourable association for lepidoptera.

Track to Kea Point and Vicinity.—The Kea Point track commences at the "Hermitage" and almost at once leads through a small patch of low bush consisting chiefly of *Phyllocladus alpinus* and *Coprosma* spp. This part of the track may be profitably worked by evening collecting, or by "sugaring" in the proper season. It may be mentioned here that "sugaring" proved quite ineffective in December and most attractive in February. After leaving this bush open scrub and tussock is passed through till the track leads on to an old moraine. Here there is a profusion of *Ranunculus Lyallii* and other subalpine plants, forming a good collecting field. Beyond Kea Point the track descends to the Mueller Glacier and presents no further entomological attractions.

About halfway to Kea Point, on the right of the track, is an isolated rounded knoll, and a little farther on lies the site of the old "Hermitage." At both of these localities there is a good variety of native shrubs and lepidoptera are in consequence fairly plentiful. On the knoll there are many plants of *Dracophyllum longifolium** and of *Hebe* spp. and these, when in flower, would doubtless repay attention.

Sealey Range.—The writer did not investigate this locality, but Mr. G. V. Hudson "found insects (in December) very abundant up to about 3,800 ft." Above that altitude there was much snow lying and insects were practically absent. Probably a month or two later the locality would be fairly prolific up to at least 5,000 feet.

Hooker Valley.—The Hooker Valley forms a fine field for the collector. Between the two swing bridges extensive banks of shingle form easy spots for the capture of *Erebia merula* and such other species as are attached to such habitats. Beyond the second bridge the valley floor consists of tussock country, mixed with scrub-covered areas. A good track runs up the valley for 7 or 8 miles, ending at the Hooker Hut. Though the valley can be worked from the "Hermitage" it would save much time if the collector arranged to occupy the hut for a few nights; this would allow of evening work in the upper portion of the area.

Mount Franklin.—Directly opposite the "Hermitage" lies Mount Franklin, which divides the Hooker and Tasman Valleys. Along the Hooker side, a few feet above the river, runs an old track, both sides of which are fringed, in many places, with shrubs of *Hebe, Dracophyllum* and *Carmichaelia,* forming a very good field for either day or evening collecting. For several hundred yards upstream from the bridge the river does not ordinarily flow close in to the side of the hill and the collector can work in the bed of the stream. Many species of *Scoparia* are to be disturbed from the river bank and *S. philetaera* was found only at this spot.

*I found many of this plant in blossom early in December and there were still a few in flower late in February.

A number of little streams flow down the mountain side, their course being marked by shallow scrub-filled gullies. To ascend the mountain one of these can be followed up till it is lost on the open grassland above. Following along the spur the climb is an easy one and a height of between 4,000 and 5,000 feet can be attained with little effort. At this elevation there are many patches of loose shingle, forming easily worked localities for *Erebia merula* and moths of the genera *Notoreas, Dasyuris,* etc. Lepidoptera, however, are comparatively rare along the top of the ridge and better success will be experienced by working down on the Tasman side of the mountain. Here there is much more vegetation though interrupted by numerous shingle slips. Towards the base of the hill tussocky areas are interspersed and the shrubby patches are often mixed with a strong growth of the fern, *Polystichum vestitum.* In such situations *Xanthorhoe helias* was plentiful.

Tasman Valley and the Vicinity of the Ball Glacier Hut.—The Ball Hut forms a convenient headquarters for working the upper end of Mount Franklin and the head of the Tasman Valley. A motor service from the "Hermitage" takes guests to within about an hour's walk of the Hut. (Before this is in print a motor-road will probably have been formed almost to the door). The building is a substantial three-roomed cottage and provides conveniences and comforts hardly to be expected at such an outpost.

After crossing the Hooker Bridge the road winds, for about half the distance, along the base of Mount Franklin, the country being largely tussock-covered ridges with intervening shrubby gullies. The valley here is very wide and flat, and, for the most part, is bare shingle. At about halfway the road leaves Mount Franklin and crosses to the moraine, on the side of which it keeps till the terminus is reached. On this upper part of the track the sides of the mountain are steeper and the vegetation, in many places, too thick and strong to admit of collecting to any advantage. Down by the track, however, there are many quite suitable spots and there is a particularly attractive looking area of scrubby bush not far from where the track leaves the mountain side. At the Hut an easily climbed spur from Mount Franklin leads to a satisfactory collecting ground, there being a considerable area which is not too steep and which is well clothed with shrubby and herbaceous plants.

The River Flats.—Where these are uniformly clothed with tussock there is not much variety of insect life, but near the streams, where more or less bare shingle occurs, several interesting species, such as *Scoparia asaleuta, S. cataxesta, Lythria catapyrrha* and *Zizina oxleyi,* may be found. One of the best of such localities runs parallel to the Hooker River before the stream passes under the traffic bridge.

Sebastopol Spur and the Red Lake.—Sebastopol Spur may be reached by crossing the Black Birch Stream either at the end of Governor's Bush track or where the stream debouches on the main valley. In either case the ascent of the spur is an easy one. Many shingle slips provide localities for species which prefer such condi-

tions and the intervening grassy slopes produce several *Crambi* and *Scopariae.*

The mountain tarn known as the Red Lake lies in a little hollow at about 4,000 feet. Its moist shores support a different lepidopterous fauna from that of the hillside. The endemic Phycitid, *Delogenes limadoxa,* is very abundant here and such damp-loving species as *Diptychophora helioctypa, Proteroeca comastis* and others occur freely. Some hundred feet above the lake the crest of the spur is passed and a level thickly grassed area dotted with a number of small tarns is reached. Here, however, in striking contrast to the abundant life round the lake, lepidoptera are extremely scarce.

LIST OF THE LEPIDOPTERA.

ARCTIIDAE.

Metacrias sp.

What appears to have been a species of *Metacrias* was seen on Mount Franklin, near the Ball Glacier Hut, in December. Several were observed but none was captured.

HYPSIDAE.

Nyctemera annulata (Boisd.), *Voy. Astr.*, 5, 197, pl. 5, 9.

Only a few examples of this usually common species were seen; the ragwort (*Senecio Jacobaea*), its favourite food plant, has not yet gained a footing in the district.

NOCTUIDAE.

Agrotis ypsilon (Rott.) *Naturf.*, 9, 141.
Several.

Ichneutica marmorata (Huds.) *Ent. Mo. Mag.*, 60, 7.
One in January.

Leucania acontistis Meyr. *Trans. N.Z. Inst.*, 19, 9.
A few in January.

L. toroneura Meyr. *Trans. Ent. Soc. Lond.*, (1901), 565.
One at the Ball Hut, in December.

L. semivittata Walk., *Cat.*, 32, 628.
Several.

Aletia moderata (Walk.) *Cat.*, 32, 705.
Common in January and February.

A. griseipennis (Feld). *Reis Nov.*, pl. 109, 22.
Very common in February.

A. cuneata Philp., *Trans. N.Z. Inst.*, 48, 420.
One in February.

A. nullifera (Walk.) *Cat.*, 11, 742.
A few in January and February.

A. cucullina (Guen.), *Ent. Mo. Mag.*, 5, 40.
One in December at the Ball Hut.

A. empyrea Huds., *Ent. Mo. Mag.*, 4 (3rd ser.), 61.
One in January on the Sebastopol track (Lindsay).

Physetica coerulea (Guen.), *Ent. Mo. Mag.*, 5, 38.
A few in January and February.

Persectania ewingii (Westw.), *Proc. Ent. Soc.* 2, 55.
Common in February.

P. propria (Walk.), *Cat.*, 9, 111.
Common in February.

P. atristriga (Walk.), *Cat.*, 33, 756.
Fairly common in February.

Melanchra maya Huds., *N.Z. Moths*, 17, pl. 4, 31.
Several taken in January and February at flowers of *Dracophyllum.*

M. mutans (Walk.), *Cat.*, 11, 602.
Common.

M. furtiva Philp., *Trans. N.Z. Inst.*, 55, 663.
Fairly common in January and February.

M. asterope Huds., *N.Z. Moths*, 24, pl. 5, 15.
Several examples in January.

M. rubescens (Butl.), *Cist. Ent.*, 2, 489.
Fairly common in January and February.

M. ochthistis Meyr., *Trans. N.Z. Inst.*, 19, 20.
One in January.

M. sequens (Howes), *Trans. N.Z. Inst.*, 44, 204.
Very common in January.

M. paracausta (Meyr.), *Trans. N.Z. Inst.*, 19, 15.
A few in December and January.

M. dotata (Walk.), *Cat.*, 11, 522.
Very common in February.

M. lithias (Meyr.), *Trans. NZ.. Inst.*, 19, 17.
A few in January and one in February.

M. morosa (Butl.), *Cist. Ent.*, 2, 543.
Common in February.

M. ustistriga (Walk.), *Cat.*, 11, 630.
A few in February.

M. agorastis Meyr., *Trans. N.Z. Inst.*, 19, 18.
Very common in February.

M. oliveri (Hamps.), *Ann. Mag. Nat. Hist.* (8), 8, 424.
One in January and two in February at flowers of *Dracophyllum longifolium.*

M. phricias (Meyr,). *Trans. N.Z. Inst.*, 20, 46.
One in February.

M. olivea Watt, *Trans. N.Z. Inst.*, 48, 413.
One in February.

Bityla defigurata (Walk.), *Cat.*, 33, 756.
One in February.

Ariathisa comma (Walk.), *Cat.*, 9, 239.
Common in January and February.

Rhapsa scotosialis Walk., *Cat.*, 34, 1150.
Several in December.

GEOMETRIDAE.

Tatosoma tipulata (Walk.), *Cat.*, 25, 1417.
Several in January and one in December.

T. alta Philp., *Trans. N.Z. Inst.*, 45, 76.
Common in January.

T. topea Philp., *Trans. N.Z. Inst.*, 35, 246.
Several in January.

Chloroclystis melochlora Meyr., *Trans. N.Z. Inst.*, 43, 58.
A few specimens, ranging from December to February.

C. punicea Philp., *Trans. N.Z. Inst.*, 54, 148.
A few in January and becoming abundant in February.

C. acompsa Prout, *Trans. N.Z. Inst.*, 58, 76.
One in January.

C. lichenodes (Purd.), *Trans. N.Z. Inst.*, 19, 70.
Common in January and February.

C. sandycias Meyr., *Trans. Ent. Soc. Lond.* (1905), 219.
Several in January.

C. neries (Meyr.), *Trans. N.Z. Inst.*, 20, 51.
Fairly common in January.

C. muscosata (Walk.), *Cat.*, 25, 1246.
One in December.

C. bilineolata (Walk.), *Cat.*, 25, 1246.
A few in December.

C. fumipalpata (Feld.) *Reis. Nov.*, pl. 131, 33.
A few in January.

Eucymatoge gobiata (Feld.), *Reis. Nov.*, pl. 131, 2.
Common, December to February.

Hydriomena hemizona Meyr., *Trans. Ent. Soc. Lond.* (1897), 385.
Common in January.

H. rixata (Feld.), *Reis. Nov.*, pl. 132, 1.
Several in February.

H. callichlora (Butl.), *Cist. Ent.*, 2, 509.
One at Governor's Bush in January (Lindsay).

Venusia charidema Meyr., *Sub-antarctic Islds.*, 1, 70.
A few in January and February.

V. undosata (Feld.), *Reis. Nov.*, pl. 128, 2.
Fairly common in December and February.

V. xanthaspis (Meyr.), *Trans. N.Z. Inst.*, 16, 61.
A few in February.

Poecilasthena pulchraria (Dbld.), *Dieff, N.Z.*, 2, 286.
Fairly common in January.

Asaphodes abrogata (Walk.), *Cat.*, 24, 1075.
Common in February.

A. parora (Meyr.), *Trans. N.Z. Inst.*, 17, 63.
Several in January and February.

A. megaspilata (Walk.), *Cat.*, 24, 1198.
Several in January and February.

Xanthorhoe clarata (Walk.), *Cat.*, 24, 1197.
Very common in January and February.

X. plumbea Philp., *Trans. N.Z. Inst.*, 47, 194.
Common in January. None of its near allies *X. eupitheciaria*, *X. cinerearia* and *X. semisignata*, was observed during this month.

X. eupitheciaria (Guen.), *Ent. Mo. Mag.*, 5, 95.
Common in February; *C. plumbea* was not observed.

X. semisignata (Walk.), *Cat.*, 24, 1200.
Common in February.

X. helias Meyr., *Trans. N.Z. Inst.*, 16, 81.
Common in February at the base of Mount Franklin near the Hooker traffic bridge.

X. cataphracta (Meyr.), *Trans. N.Z. Inst.*, 16, 79.
A few in February.

X. orophyla (Meyr.), *Trans. N.Z. Inst.*, 16, 71.
Common in February.

X. semifissata (Walk.), *Cat.*, 25, 1320.
Fairly common in February.

X. chlamydota (Meyr.), *Trans. N.Z. Inst.*, 16, 72.
Two at Governor's Bush in January and one in the Hooker Valley in February.

X. cedrinodes Meyr., *Trans. N.Z. Inst.*, 43, 72.
A single worn example in January.

X. stricta Philp., *Trans. N.Z. Inst.*, 47, 195.
One in February.

X. cymozeucta Meyr., *Trans. N.Z. Inst.*, 42, 25.
One at Governor's Bush in January (Lindsay).

Notoreas zopyra (Meyr.), *Trans. N.Z. Inst.*, 16, 89.
Common in January and February in the bed of the Black Birch Stream.

N. brephos (Walk.), *Cat.*, 24, 1037.
Not uncommon; December to February.

N. anthracias (Meyr.), *Trans. N.Z. Inst.*, 16, 84.
A few near the Ball Hut in February.

N. paradelpha (Meyr.), *Trans. N.Z. Inst.*, 16, 86.
One near the Ball Hut in February.

Dasyuris anceps (Butl.), *Proc. Zool. Soc. Lond.* (1877), 392, pl. 43, 3.
Fairly common near the Ball Hut in February.

D. austrina Philp., *Trans. N.Z. Inst.*, 58, 359.
There is an example of this species, labelled "Mt. Cook, T. Hall," in the Auckland Museum collections.

D. transaurea Howes, *Trans. N.Z. Inst.*, 44, 203.
One near the Ball Hut in February.

D. leucobathra Meyr., *Trans. N.Z. Inst.*, 43, 59.
A few worn specimens in February.

Lythria catapyrrha (Butl.), *Proc. Zool. Soc. Lond.* (1877), 392, pl. 43, 2.
Not uncommon on shingly localities in December and January.

L. regilla Philp., *Trans. N.Z. Inst.*, 58, 360.
A few in December, January and February.

Dichromodes gypsotis Meyr., *Trans. N.Z. Inst.*, 20, 60.
One in January on Mt. Franklin opposite the "Hermitage" (Lindsay).

Epirranthis alectoraria (Walk.), *Cat.*, 20, 259.
A single worn specimen in January.

E. hemipteraria (Guen.), *Lep.*, 9, 220, pl. 6, 2.
A few in January and February.

Selidosema monacha Huds., *Trans. N.Z. Inst.*, 35, 245, pl. 30, 4.
Fairly common in December, January and February.

S. leucelaca Meyr., *Trans. N.Z. Inst.*, 41, 6.
Several in January and February. The males of this species are frequently only to be differentiated with great difficulty from those of the former species.

S. indistincta (Butl.), *Proc. Zool. Soc. Lond.* (1877), 394, pl. 43, 8.
Abundant in February. The Mt. Cook race has the white band preceding the subterminal line almost always present.

S. productata (Walk.), *Cat.*, 24, 1197.
Common, December to February.

S. dejectaria (Walk.), *Cat.*, 21, 394.
Several in February.

S. suavis (Butl.), *Cist. Ent.*, 2, 497.
Abundant in December.

Sestra humeraria (Walk.), *Cat.*, 23, 940.
One in December.

S. flexata (Walk.), *Cat.*, 25, 1421.
Common in December.

Azelina fortinata (Guen.), *Ent. Mo. Mag.*, 5, 41.
Common, December to February.

Declana niveata Butl., *Cist. Ent.*, 2, 500.
Fairly common in February.

D. floccosa Walk., *Cat.*, 15, 1649.
A few in February.

D. junctilinea Walk., *Cat.*, 32, 643.
Common in February.

D. egregia (Feld.), *Reis. Nov.*, pl. 131, 24.
One in January at flowers of *Dracophyllum longifolium*.

D. glacialis Huds., *Trans. N.Z. Inst.*, 35, 245.
Several in January.

Nymphalidae.

Argyrophenga antipodum Dbld., *Ann. Mag. Nat. Hist.*, 16 (1845), 307.
Common, December to February. The race does not differ from the southern lowland form.

Erebia merula Hew., *Ent. Mo. Mag.*, 12, 10 (1875).
Fairly common in December and January; not observed in February.

E. butleri (Fered.), *Trans. N.Z. Inst.*, 12, 264.
None seen, but Dr. Tillyard took the species commonly in March.

Pyrameis gonerilla (Fabr.), *Syst. Ent.*, 498, 237.
Common in February.

Lycaenidae.

Chrysophanus sallustius Fabr., *Syst.*, *Ent.*, 11, 310.
Common in January and February.

C. boldenarum (White), *Proc. Ent. Soc.* (3), 1, 26.
Abundant, December and February.

Zizina oxleyi (Feld.), *Reis. Nov.*, pl. 2, 280.
Common in February along the Hooker river-bed near the traffic bridge. *Oxleyi* is usually regarded as being a smaller species than *labradus*, but the Mt. Cook race is quite as large as that species.

Phycitidae.

Delogenes limodoxa Meyr., *Trans. N.Z. Inst.*, 50, 132.
Common in January and February, usually in more or less damp situations.

Crambidae.

Orocrambus caesius Philp., *Trans. N.Z. Inst.*, 56, 390.
Several in January and February.

O. melampetrus Meyr., *Trans. N.Z. Inst.*, 17, 133.
One in December in the Hooker Valley.

Crambus corruptus (Butl.), *Proc. Zool. Soc. Lond.* (1877), 399, pl. 43, 9.
Two examples in December near the Ball Hut.

C. antimorus Meyr., *Trans. Ent. Soc. Lond.* (1901), 567.
Common in December and January.

C. heteranthes Meyr., *Trans. Ent. Soc. Lond.* (1901), 568.
Common in December and January.

C. apselias Meyr., *Trans. N.Z. Inst.*, 39, 108.
Common in February. A few in December at Ball Hut.

C. dicrenellus Meyr., *Trans. N.Z. Inst.*, 15, 22.
Common in February.

C. vitellus Dbld., *Dieff. N.Z.*, 2, 289.
Fairly common in January and February. A rather large race, more whitish than usual.

C. callirrhous Meyr., *Trans. N.Z. Inst.*, 15, 24.
Several in February.

C. simplex (Butl.), *Proc. Zool. Soc. Lond.* (1877), 400, pl. 43, 12.
Common in February.

C. vulgaris Butl., *Proc. Zool. Soc. Lond.* (1877), 400, pl. 43, 7.
Common in February.

C. flexuosellus Dbld., *Dieff. N.Z.*, 2, 289.
Common in February.

C. obstructus Meyr., *Ent. Mo. Mag.* (1911), 82.
Common in February.

Tauroscopa gorgopis Meyr., *Trans. N.Z. Inst.*, 20, 69.
What appears to be a small female of this species was taken at the Ball Hut in December and a few were secured by Mr. Lindsay near Kea Point in January.

Diptychophora helioctypa Meyr., *Trans. N.Z. Inst.*, 15, 17.
Common in January and February near the Red Lake.

D. elaina Meyr., *Trans. N.Z. Inst.*, 15, 17.
A few in January.

D. interrupta (Feld.), *Reis. Nov.* pl. 135, 15.
Common in January and February.

D. pyrsophanes Meyr., *Trans. N.Z. Inst.*, 15, 11.
Common in January and February.

D. epiphaea Meyr., *Trans. N.Z. Inst.*, 17, 132.
Common in January.

Gadira acerella Walk., *Cat.*, 35, 1742.
Several in January and one in February.

PYRAUSTIDAE.

Musotima nitidalis (Walk.), *Cat.*, 34, 1317.
Common in December and January.

Mecyna maorialis (Feld.), *Reis. Nov.*, pl. 134, 34.
Several in December and January.

M. flavidalis (Dbld.), *Dieff, N.Z.*, 2, 287.
Common in February.

M. notata (Butl.), *Cist. Ent.*, 2, 493.
Several in February.

Proteroeca comastis Meyr., *Trans. Ent. Soc. Lond.* (1884), 335.
Common in January and February at the Red Lake.

Heliothela atra (Butl.), *Proc. Zool. Soc. Lond.* (1877), 404.
Common in January.

Scoparia cyptastis Meyr., *Trans. N.Z. Inst.*, 41, 7.
Common, December to February. The large dark race, found also at Arthur's Pass.

S. melanaegis Meyr., *Trans. N.Z. Inst.*, 17, 92.
Several in January.

S. chalara Meyr., *Trans. Ent. Soc. Lond.* (1901), 570.
Common, December and January.

S. octophora Meyr., *Trans. N.Z. Inst.*, 17, 118.
Common in February.

S. tetracycla Meyr., *Trans. N.Z. Inst.*, 19, 97.
Not uncommon, December to February.

S. parmifera Meyr., *Sub-antaractic Islds.*, 72.
Common in January. A rather small race.

S. organaea Meyr., *Trans. Ent. Soc. Lond.* (1901), 569.
Several, December to February.

S. thyridias Meyr., *Trans. Ent. Soc. Lond.* (1905), 229.
A few in January.

S. philerga Meyr., *Trans. N.Z. Inst.*, 17, 81.
Several in January and February.

S. cymatias Meyr., *Trans. N.Z. Inst.*, 17, 86.
One in January.

S. galactalis Huds., *Ent. Mo. Mag.* (1913), 250.
Common in January and February.

S. steropaea Meyr., *Trans. N.Z. Inst.*, 17, 103.
Common in January and February.

S. asaleuta Meyr., *Trans. N.Z. Inst.*, 39, 111.
Common in January on shingle near the Hooker River-bed.

S. cataxesta Meyr., *Trans. N.Z. Inst.*, 17, 96.
Common in December and January in the same situation as the preceding species.

S. paltomacha Meyr., *Trans. N.Z. Inst.*, 17, 105.
Several in December and January.

S. crypsinoa Meyr., *Trans. N.Z. Inst.*, 17, 102.
Common in December and January.

S. psammittis Meyr., *Trans. N.Z. Inst.*, 17, 99.
Common in January.

S. feredayi Knaggs., *Ent. Mo. Mag.*, 4, 80.
Common, December to February.

S. philetaera Meyr., *Trans. N.Z. Inst.*, 17, 93.
Common in February round the base of Mt. Franklin near the Hooker River traffic bridge.

S. asterisca (Meyr.), *Trans. N.Z. Inst.*, 17, 118.
Common in February.

S. trivirgata (Feld.), *Reis. Nov.*, pl. 137, 29.
Common, December to February.

S. deltophora (Meyr.), *Trans. N.Z. Inst.*, 17, 106.
One in February.

S. niphospora (Meyr.), *Trans. N.Z. Inst.*, 17, 115.
Several in February.

S. characta Meyr., *Trans. N.Z. Inst.*, 17, 90.
Common in February.

S. minusculalis Walk., *Cat.*, 34, 1503.
One in February.

S. dinodes Meyr., *Trans. N.Z. Inst.*, 17, 85.
One in February.

S. axena Meyr., *Trans. N.Z. Inst.*, 17, 103.
A few in February at the Ball Hut.

S. cyameuta (Meyr.), *Trans. N.Z. Inst.*, 17, 112.
Common in February.

S. exilis Knaggs, *Ent. Mo. Mag.*, 4, 81.
I did not meet with this species, but Hudson records it (B. and M. of N.Z., 197).

S. halopis Meyr., *Sub-antarctic Islds.*, 72.
Several in February.

S. sabulosella (Walk.), *Cat.*, 27, 17, 8.
Common, December to February.

S. ergatis Meyr., *Trans. N.Z. Inst.*, 17, 88.
Common in December.

S. microphthalma Meyr., *Trans. N.Z. Inst.*, 17, 87.
One in the Hooker Valley in January (Lindsay).

S. nomeutis Meyr., *Trans. N.Z. Inst.*, 17, 116.
One in the Hooker Valley in January (Lindsay).

PTEROPHORIDAE.

Platyptilia falcatalis Walk., *Cat.*, 30, 931.
Several in February.

P. deprivatalis Walk., *Cat.*, 30, 946.
Several in February.

Alucita monospilalis (Walk.), *Cat.*, 30, 950.
Common in February.

Stenoptilia charadrias (Meyr.), *Trans. N.Z. Inst.*, 17, 126.
Fairly common in February.

TORTRICIDAE.

Catamacta rureana Feld., *Reis Nov.*, pl. 137, 47.
One in February.

Eurythecta eremana (Meyr.), *Trans. N.Z. Inst.*, 17, 144.
Several in February.

Ascerodes prochlora Meyr., *Trans. Ent. Soc. Lond.* (1905), 234.
One in February near the Ball Hut.

Tortrix conditana Walk., *Cat.*, 28, 306.
One in February.

T. excessana (Walk.), *Cat.*, 28, 303.
Common in January and February. A large reddish race.

T. alopecana Meyr., *Trans. N.Z. Inst.*, 17, 147.
Several bred from larvae found feeding on *Phyllocladus alpinus*. The moths emerged early in February (Lindsay).

T. flavescens (Butl.), *Proc. Zool. Soc. Lond.* (1877), 402.
Several in December.

T. molybditis Meyr., *Trans. N.Z. Inst.*, 39, 116.
Several in January.

Ctenopseustis obliquana (Walk.), *Cat.*, 28, 302.
Fairly common in February.

Epichorista persecta Meyr., *Trans. N.Z. Inst.*, 46, 104.
A few in January and February.

E. aspistana (Meyr.), *Trans. N.Z. Inst.*, 15, 42.
A few in January and February.

E. emphanes (Meyr.), *Trans. Ent. Soc. Lond.* (1901), 571.
Several taken in January (Lindsay).

Harmologa oblongana (Walk.), *Cat.*, 28, 303.
A few in February.

Gelophaula trisulca (Meyr.), *Trans. N.Z. Inst.*, 48, 44.
One in January on Mt. Franklin opposite the "Hermitage" (Lindsay).

Gelechiidae.

Thiotricha tetraphala Meyr., *Trans. N.Z. Inst.*, 18, 164.
Several in February.

Phthorimaea thyraula (Meyr.), *Trans. N.Z. Inst.*, 18, 167.
One in February.

P. cheradias (Meyr)., *Trans. N.Z. Inst.*, 41, 12.
Several in January near the Red Lake.

P. glaucoterma (Meyr.), *Trans. N.Z. Inst.*, 43, 63.
One in January.

Gelechia monophragma Meyr., *Trans. N.Z. Inst.*, 18, 169.
Common in December and January.

Anisoplaca fraxinea Philp., *Trans. N.Z. Inst.*, 58, 364.
Common in February.

A. ptyoptera Meyr., *Trans. N.Z. Inst.*, 18, 171.
One in February.

Oecophoridae.

Borkhausenia armigerella (Walk.), *Cat.*, 29, 698.
Common, December to February.

B. siderodeta (Meyr.), *Trans. N.Z. Inst.*, 16, 43.
A few in January.

B. xanthomicta (Meyr.), *Trans. N.Z. Inst.*, 48, 415.
One in January.

B. grata Philp., *Trans. N.Z. Inst.*, 58, 85.
One in January.

B. innotella (Walk.), *Cat.*, 29, 652.
A few in February.

B. terrena Philp., *Trans. N.Z. Inst.*, 56, 391.
A few in February.

B. siderota (Meyr.), *Trans. N.Z. Inst.*, 20, 82.
One in December.

B. eriphaea Meyr., *Trans. N.Z., Inst.*, 46, 107.
Several in December.

B. thalerodes Meyr., *Trans. N.Z. Inst.*, 48, 416.
A few in December.

B. crotala Meyr., *Trans. N.Z. Inst.*, 47, 213.
Not uncommon in January.

B. nycteris (Meyr.), *Trans. N.Z. Inst.*, 22, 219.
Common in January.

Thamnosara sublitella (Walk.), *Cat.*, 29, 654.
Not uncommon in January.

Gymnobathra parca (Butl.), *Proc. Zool. Soc. Lond.* (1877), 405.
Common in January.

G. coarctatella (Walk.), *Cat.*, 29, 768.
A few in December.

Trachypepla ingenua Meyr., *Trans. N.Z. Inst.*, 43, 65.
One in February.

T. anastrella Meyr., *Trans. N.Z. Inst.*, 16, 19.
One in February.

Izatha convulsella (Walk.), *Trans. N.Z., Inst.*, 47, 200.
One in January.

Euchersadaula lathriopa (Meyr.), *Trans. Ent. Soc. Lond.* (1905), 237.
Several in December. Rather greyer than usual.

Philobota amenena Meyr., *Trans. N.Z. Inst.*, 20, 78.
Two in January.

Cryptolechia apocrypta (Meyr.), *Trans. N.Z. Inst.*, 18, 172.
Common in December to February.

Eutorna caryochroa Meyr., *Trans. N.Z. Inst.*, 21, 158.
Common in January and February.

CARPOSINIDAE.

Carposina gonosemana (Meyr.), *Trans. N.Z. Inst.*, 15, 67.
One in February.

C. maculosa Philp., *Trans. N.Z. Inst.*, 57, 705.
One in January on the Sebastopol track (Lindsay).

GLYPHIPTERYGIDAE.

Heliostibes electrica Meyr., *Trans. N.Z. Inst.*, 21, 157.
One in February.

Simaethis microlitha Meyr., *Trans. N.Z. Inst.*, 20, 84.
A single female taken in February appears to be this species.

S. symbolaea Meyr., *Trans. N.Z. Inst.*, 20, 85.
One in December.

S. tillyardi Philp., *Trans. N.Z. Inst.*, 55, 666.
March. The specimen captured by Dr. Tillyard remains unique.

Glyphipteryx erastis Meyr., *Trans. N.Z. Inst.*, 43, 76.
Several in January.

G. codonias Meyr., *Trans. N.Z. Inst.*, 41, 15.
A few in January.

G. achlyoessa (Meyr.), *Proc. Linn. Soc. N.S.W.*, (1880), 252.
Several in December.

G zelota Meyr., *Trans. N.Z. Inst.*, 20, 86.
A few in January and February.

G. dichorda Meyr., *Trans. N.Z. Inst.*, 43, 76.
One in January on Mt. Franklin opposite the "Hermitage."

G. leptosema Meyr., *Trans. N.Z. Inst.*, 20, 87.
Several in February.

Elachistidae.

Elachista helonoma Meyr., *Trans. N.Z. Inst.*, 21, 178.
Common in February.

E. ombrodoca Meyr., *Trans. N.Z. Inst.*, 21, 179.
Common in December.

Hyponomeutidae.

Zelleria copidota (Meyr.), *Trans. N.Z. Inst.*, 21, 163.
Common in January.

Gracilariidae.

Gracilaria elaeas Meyr., *Trans. N.Z. Inst.*, 43, 66.
Common in January.

G. selenitis Meyr., *Trans. N.Z. Inst.*, 41, 15.
Several in December.

Plutellidae.

Dolichernis chloroleuca Meyr., *Trans. N.Z. Inst.*, 23, 99.
Common in February.

Orthenches porphyritis Meyr., *Trans. N.Z. Inst.*, 18, 176.
Common, December to February.

O. semifasciata Philp., *Trans. N.Z. Inst.*, 47, 200.
A single male in February. The specimen is larger (19 mm.) than usual.

Plutella maculipennis Curt., *Brit. Ent.*, pl. 420.
Several in February.

Tineidae.

Mallabathra subalpina Philp., *Rec. Cant., Mus.*
Several near the Red Lake in January.

M. fragilis Philp., *Trans. N.Z. Inst.*, 57, 708.
One in December.

NEPTICULIDAE.

Nepticula progonopis Meyr., *Trans. N.Z. Inst.*, 53, 336.
Several in December.

N. lucida Philp., *Trans. N.Z. Inst.*, 51, 225.
Common in December.

HEPIALIDAE.

Porina umbraculata (Guen.), *Ent. Mo. Mag.*, 5, 1.
Common in January.

P. fusca Philp., *Trans. N.Z. Inst.*, 46, 121.
Several in January.

P. aurimaculata Philp., *Trans. N.Z. Inst.*, 46, 121.
The type specimen was obtained from the "Hermitage" in 1913 by Mr. F. S. Oliver. A second example, now in the collection Cawthron Institute, was forwarded to the writer by the manager of the Mount Cook Motor Company in 1928.

MNESARCHAEIDAE.

Mnesarchaea paracosma Meyr., *Trans. N.Z. Inst.*, 18, 180.
Fairly common in January.

MICROPTERYGIDAE.

Sabatinca sp.
A single specimen, not in determinable condition, but probably *S. chrysargyra* Meyr., was taken in January.

Note.—There are two species taken by Fereday and described by Meyrick (*Trans. Ent. Soc. Lond.*, 1901) which are not included in the above list. These are *Scoparia torodes* Meyr. and *S. alopecias* Meyr. The former, I am inclined to think, is the same insect as *S. galactalis* Huds. Regarding the latter, Mr. Lindsay informs me that a species under that name in the Fereday collection looks like a faintly marked *S. ergatis* Meyr. This example may not, however, be authentic; *ergatis* occurs commonly at Mount Cook and was well known to Mr. Meyrick who had both sexes of his *alopecias* before him for description.

DESCRIPTION OF NEW SPECIES.

SELIDOSEMIDAE.

Selidosema adusta n. sp.
♂ ♀. 29-39 mm. Head, palpi and thorax ochreous mixed with brown. Antennae grey mixed with brown, in ♂ moderately bipectinated. Abdomen pale ochreous sprinkled with fuscous. Legs pale ochreous, anterior pair fuscous, tarsi annulated with ochreous. Forewings elongate-triangular, costa strongly arched, apex subrectangular (in ♀ more acute), termen bowed, oblique; greyish-brown (in one example somewhat ochreous); lines blackish-fuscous, often very obscure; 1st line double, excurved above middle; median line irregular, indented below middle; 2nd line rather sinuate; subterminal

dentate, slightly excurved above middle and incurved below, obscurely pale-margined posteriorly; a series of triangular black dots round termen: fringes grey with obscure brown basal line. Hindwings sub-oblong, termen slightly projecting on vein 4, dorsum broadly rounded; greyish-white, finely sprinkled with fuscous posteriorly: fringes whitish-grey.

Closely allied to *S. fenerata* Feld. and *S. argentaria* Philp. From the former it is at once distinguished by the rounded (not angled) dorsum of the hindwings; from the latter it may be separated by the less prominent projection on the termen of hindwings at vein 4, by the broader forewings and the browner ground colour.

Governor's Bush. Common in December. Holotype (♂) allotype (♀) and paratypes in collection Canterbury Museum; paratypes in collection Dominion Museum and Cawthron Institute.

PYRAUSTIDAE.

Scoparia sinuata n. sp.

♂ ♀. 18-19 mm. Head and palpi brown mixed with white. Antennae bright brown, minutely ciliated in ♂. Thorax brown. Abdomen greyish-ochreous. Legs whitish-ochreous, anterior pair fuscous, tarsi obscurely annulated with ochreous. Forewings short, costa almost straight, apex almost rectangular, termen nearly straight, little oblique; pale brown mixed with blackish along costa basally; 1st line white, slightly outwards-curved, indented at middle, posteriorly margined with black; 2nd line white, parallel to termen, slightly sinuate beneath costa, incurved above dorsum; an obscure subterminal whitish shade, remote from 2nd line; orbicular and claviform hardly indicated; reniform obscurely X-shaped, black, lower fork filled with whitish: fringes brown with darker basal line. Hindwings very pale ochreous clouded with brown: fringes ochreous-white with a dark basal line round apex.

The shape of the 2nd line is somewhat similar to that of *S. chalara* Meyr., but *sinuata* is much smaller and less ochreous in colour.

Three males and a female in February. Holotype (♂) and a female in collection Canterbury Museum and a male in the collections Dominion Museum and Cawthron Institute. As the female is in poor condition, I have refrained from making it the allotype.

Scoparia limatula n. sp.

♂ ♀. 26 mm. Head, palpi and thorax grey. Antennae brown, minutely ciliated. Abdomen ochreous. Legs white, anterior pair infuscated, posterior pair somewhat ochreous. Forewings elongate-triangular, costa straight, arched towards apex, apex rectangular, termen slightly sinuate, little oblique; white, densely strewn with grey and fuscous scales, the latter tending to form numerous linear dots, particularly on the apical third of wing: stigmata and lines almost obsolete; 2nd line white, faintly indicated, its course marked by a series of fuscous dots, strongly excurved beneath costa, thence incurved to before dorsum; a series of fuscous spots round termen:

fringes greyish-white with two darker grey lines. Hindwings and fringes brassy-ochreous.

Not very close to any other *Scoparia* but perhaps related to the *petrina* group.

The type material consists of a male from Bold Peak (Wakatipu) taken in 1913 by Mr. G. Howes, another male secured by myself at Invercargill in January, 1916, and a female taken at Mount Cook in February. Holotype (♂) and a male paratype in collection Cawthron Institute; allotype (♀) in collection Canterbury Museum.

OECOPHORIDAE.

Leptocroca obliqua n. sp.

♂. Head ochreous. Palpi ochreous mixed with fuscous. Antennae fuscous, obscurely mixed with ochreous, ciliations in ♂ 1. Thorax greyish-brown. Abdomen grey, brassy tinged dorsally, segmental divisions paler. Legs ochreous, anterior pair infuscated. Forewings elongate, costa rather strongly arched, apex round-pointed, termen strongly oblique; whitish-grey; markings greyish-brown; a stripe on base of costa to two-fifths, attenuated apically and enclosing a dark blotch before apex; an oblique nearly straight fascia from half to tornus, the area between this and termen being more mixed with pinkish brown; stigmata blackish; 1st discal above plical; 2nd discal enclosed in median fascia; an interrupted series of blackish scales round apex and termen: fringes ochreous-grey, tinged with pink round apex. Hindwings shining grey: fringes whitish-grey.

Nearest to *L. variabilis* Philp; the oblique median fascia and the darker apical portion of forewing are good distinguishing characters. The male genitalia, which can usually be sufficiently examined without dissection, display quite satisfactory differentiating features.

Two males in January. Holotype in collection Canterbury Museum; paratype in collection Dominion Museum.

CARPOSINIDAE.

Carposina canescens n. sp.

♂ ♀. 15-17 mm. Head, palpi and thorax whitish-grey. Antennae grey, ciliations in ♂ 4. Abdomen whitish-ochreous. Legs, anterior and middle pair fuscous, tarsi annulated with ochreous, posterior pair ochreous-white. Forewings, costa moderately arched, apex rounded, termen straight, oblique; grey, faintly greenish tinged; a black basal area on costa reaching half across wing and indicated below middle by a few raised black scales; 5 or 6 black spots on costa between $\frac{1}{3}$ and apex; an oblique black bar of raised scales beneath 1st costal spot, outwardly margined with ochreous and white; 3 or 4 ring-like spots and some scattered blackish and ochreous scales in disc; an obscure interrupted blackish subterminal fascia; termen thickly sprinkled with blackish scales: fringes fuscous-grey sprinkled with white. Hindwings shining grey, in ♂ with ochreous area along costa from base to $\frac{1}{2}$; fringes ochreous-white.

Approaching *C. epomiana* Meyr., but a smaller and narrower-winged species.

Four males and one female in Governor's Bush in February. Holotype (♂) and allotype (♀) in collection Canterbury Museum; two male paratypes in collection Cawthron Institute and one male paratype in collection Dominion Museum.

C. ignobilis n. sp.

♂. 16 mm. Head, palpi and thorax grey mixed with brown. Antennae ochreous-grey spotted with fuscous, ciliations in ♂ 3. Abdomen ochreous. Legs ochreous, anterior pair infuscated. Forewings narrow, hardly dilated posteriorly, costa rather strongly arched, apex round-pointed, termen very oblique; ochreous-grey densely irrorated with fuscous; basal patch indicated by blackish scales, more prominently below fold; an oblique blackish scale-tuft crossing fold at about $\frac{1}{4}$, suffusedly margined inwardly with a fuscous shade which extends right across wing; some very obscure dark spots on apical $\frac{2}{3}$ of costa; an obscure blackish spot in disc at $\frac{3}{4}$: fringes densely speckled with fuscous and whitish. Hindwings shining grey: fringes whitish-ochreous.

An obscure species, perhaps related to the preceding form, but lacking the ochreous patch on costa of hindwing and having quite different genitalic characters.

A single male taken in Governor's Bush in February. Holotype in collection Canterbury Museum.

Glyphipterygidae.

Hierodoris eremita n. sp.

♀. 22-24 mm. Head whitish-ochreous. Palpi, ochreous-whitish mixed outwardly with brown. Antennae whitish, closely annulated with fuscous. Thorax leaden white. Abdomen whitish-ochreous. broadly banded with dark fuscous dorsally. Legs ochreous white. Forewings oblong, costa strongly arched, apex broadly rounded, termen rounded, not oblique; shining white, faintly ochreous tinged towards termen: fringes white. Hindwings ochreous white, iridescent; apical half fuscous: fringes white.

Not at all like any other species of the genus. The resemblance to a female *Gelophaula* is most marked.

Five females in December, three in the Hooker Valley and two near the Ball Glacier Hut. Holotype (♀) and a paratype in collection Canterbury Museum; two paratypes in collection Cawthron Institute and one paratype in collection Dominion Museum.

Elachistidae.

Elachista napaea n. sp.

♂. 9-10 mm. Head and thorax grey. Palpi greyish-white. Antennae fuscous. Abdomen dark grey, anal tuft ochreous. Legs ochreous, tarsi annulated with blackish fuscous. Forewings hardly dilated posteriorly, apex blunt; whitish-grey with some ochreous and numerous blackish scales; a series of blackish dots along fold from

near base to about $\frac{1}{3}$, sometimes absent; an ochreous blotch on fold at about $\frac{1}{2}$, containing a linear black mark, sometimes very obscure, but seldom absent; sometimes the black scales tend to form a linear mark in disc at $\frac{3}{4}$: fringes grey speckled with black except on tornal $\frac{1}{2}$ where they are greyish fuscous. Hindwings and fringes fuscous-grey.

Resembles *E. ombrodoca* Meyr., but a larger insect. The male genitalia offer good distinguishing characters.

Common in Governor's Bush in December. No females were taken. Holotype (♂) and paratypes in collection Canterbury Museum; and paratypes in collections Dominion Museum and Cawthron Institute.

ACKNOWLEDGEMENTS.

I have gratefully to acknowledge the assistance received from the New Zealand Institute in the shape of a Research Grant which covered the expenses of the last two visits to the locality. To Mr. and Mrs. Stewart Lindsay my thanks are due for hospitality extended during the very successful trip in January, 1929, and I am also much indebted to Mr. Lindsay for information regarding the Mount Cook material in the Fereday collection. Mr. Lindsay further placed me in his debt by going through my list and adding several species which I had failed to observe. For the loan of literature, apparatus and specimens I wish to express my best thanks to the Cawthron Institute, and to Mr. E. S. Gourlay, of that institution, who spared no pains to assist me in many ways. I am also indebted to Miss A. Castle, of the Dominion Museum, for help of a similar nature. Finally, I have to thank the Director and Board of the Auckland Institute and Museum for facilities cordially extended towards the preparation of this paper.

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A Lingulid from the Tertiary Rocks of the Waikato District.

By W. H. A. PENSELER, M.Sc., B.E., A.O.S.M.

[*Read before the Wellington Philosophical Society, 11th June, 1930; received by the Editor, 13th June, 1930; issued separately, 18th November, 1930.*]

PLATE 68.

INTRODUCTION.

THE fossils described in this paper were obtained from two of the coal mines in the Lower Waikato Basin where, owing to the occurrence of faults, it was found necessary to construct inclined drives through rock from one portion of the coal seam to the displaced portion. Fossils were found in part of the strata passed through, and it is unfortunate that at the time no collection was made apart from one or two specimens kept as "curios." The rock removed in mining was either thrown on the waste dump and subsequently covered over or used in filling old workings, and so is now inaccessible. The rock forming the sides and roof in these drives is badly weathered by the mine air, and for this reason and owing to the timbering required, the number of specimens that can be obtained from their place of origin is small. Outcrops, on account of weathering, afford no opportunity for the collection of fossils.

The collection described and now lodged with the palaeontological collections of the N.Z. Geological Survey, Wellington, consists of a few specimens obtained from the sides and roof of the inclined drives together with a small number which had been kept as "interesting curios." Although the total number is small, and the specimens imperfect, it is felt that they should be described and their occurrence recorded because brachiopods of this family have not up till now been recorded in New Zealand.

The writer's best thanks are due to Messrs. A. Burt, P. Hunter and C. Hunter, managers of Pukemiro, Glen Afton and Renown Collieries respectively, for their kindness in placing much information at his disposal and in affording him all facilities for making investigations.

GENERAL GEOLOGY.

The rock containing the fossils to be described is a light grey claystone forming a bed about 40 feet thick resting conformably on the claystones of the Coal Measure Series of the Lower Waikato Basin. In appearance, these two claystones are similar but may be distinguished, e.g., in borehole records, by the fact that the coal measure claystones (locally known as "fireclays") are usually of a brownish colour and contain frequent dark coloured bands, carbonaceous layers, and nodules of spathic iron ore, whereas the over-

lying claystone with the fossil fauna is practically uniform. In the process of mining, as in stone drives or cross-measure drifts, the claystones of the coal measures are seen to contain bedded leaf remains and irregularly distributed coalified vegetal matter (see Penseler, 1930) which are absent (except in rare instances and in small amount) from the overlying claystone. The difference is therefore that the one rock contains a fossil flora and the other a fossil fauna, the former being a fresh water deposit and the latter a brackish water to marine deposit. The name "Lingula Claystone" is proposed for the latter bed.

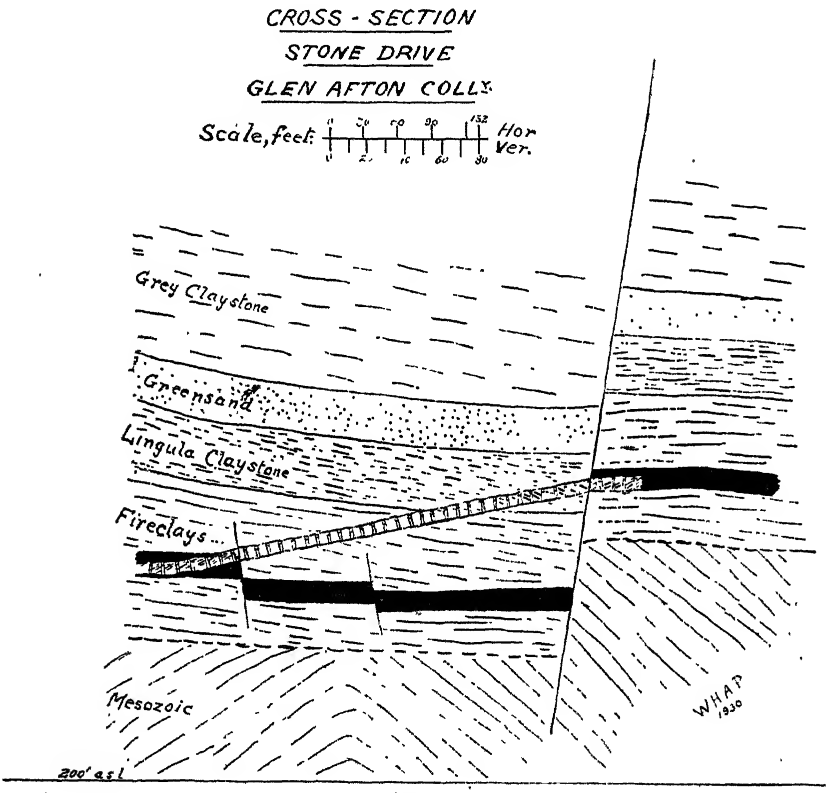


Fig. 1.

Overlying the Lingula Claystone is a bed, about 25 to 30 ft. thick, of bluish green glauconitic sandstone, more or less argillaceous and calcareous in places, which is followed by a thick bed of dark grey claystone. These three beds together are classed as equivalent to the Whaingaroa Series of Henderson and Grange (1926), and with the underlying Coal Measure Series and the overlying Te Kuiti limestones have been placed by Henderson (1929) in the Ototaran Stage of Oligocene Age. The Te Kuiti beds may possibly be of lower Miocene Age, but the Lingula Claystone may definitely be regarded as of Oligocene age.

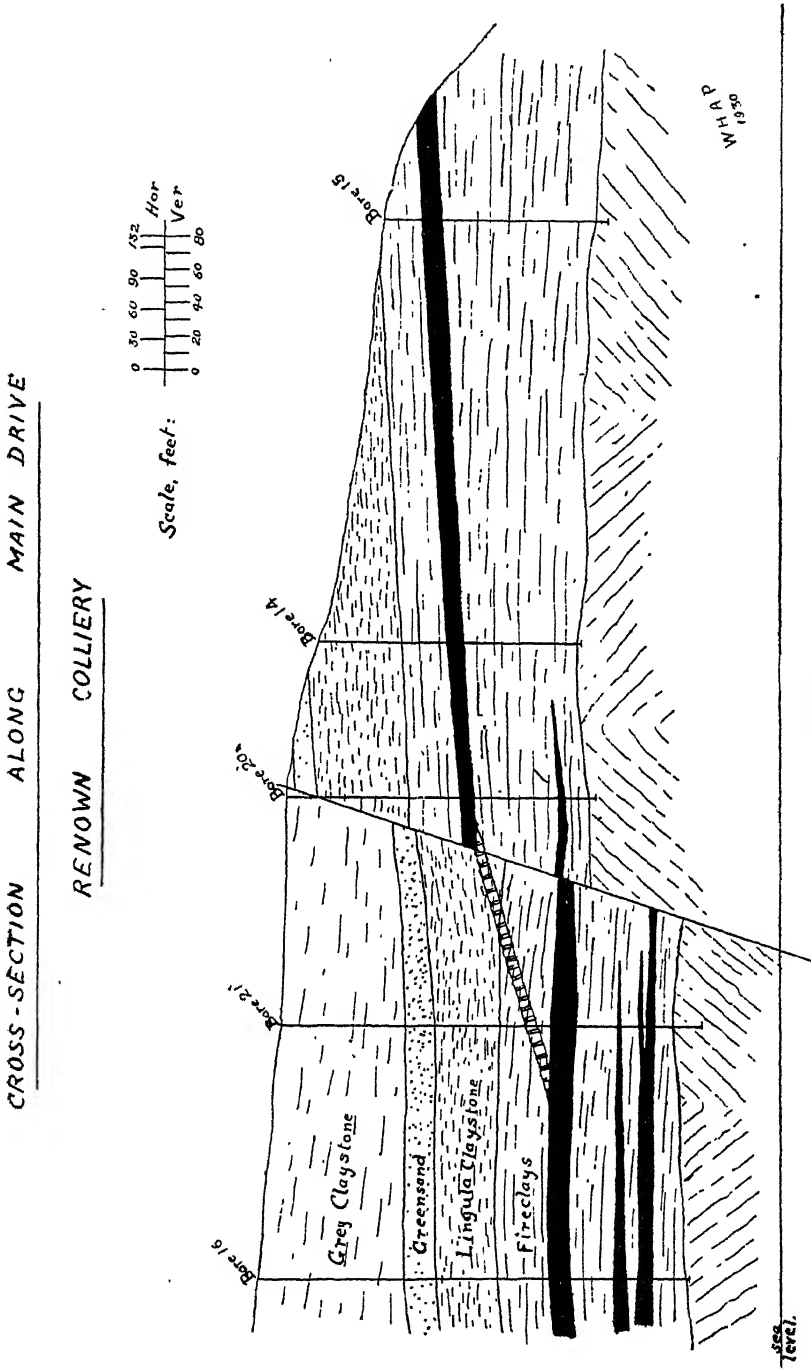

CROSS-SECTION ALONG MAIN DRIVE
RENOWN COLLIERY
Scale, feet:
0 30 60 90 132 Hor
0 20 40 60 80 Ver
Bore 15
Bore 14
Bore 20
Bore 21
Bore 16
Grey Claystone
Greensand
Lingula Claystone
Fireclays
WHAP 1930
sea level.

FIG. 2.

The Whaingaroa Series represents the first deposits of a marine facies which were laid down on the fresh water (estuarine) coal measure muds as the land was submerged, and the first stage of this submergence, necessarily a shallow water stage, resulted in the deposition of fine grained muds which show no evidence of bedding. Fossils occur scattered irregularly in these clays and may sometimes be missing. The position of this bed with respect to the enclosing rocks is shown in Figs. 1 and 2.

In Fig. 1, a stone drive in the Glen Afton Colliery, the claystones appear uniform to the eye from the base of the drive to the top and no break is noticeable between the coal measure claystone and the Lingula Claystone. Fossils were collected from near the top of the drive, about 50 feet above the top of the coal seam.

In driving the dip shown in Fig. 2 at the Renown Colliery, Waikokowai, lingulids were obtained in the upper part of the drive but were absent in the lower part which passed into the coal measure fireclays where leaf remains were common. Here again no break between the two claystones was seen.

In the Pukemiro Colliery a similar stone drive connects one portion of the seam with the faulted portion about 90 feet higher, and here the stone drive must have passed through the Lingula Claystone. This drive was constructed about 12 years or more ago and there is no record of any fossil having been found, nor can any be seen now in the sides of the drive. Possibly the fossils are missing from this locality or may occur higher in the bed because the drive passed through the lower part only. Again no break can be seen in the succession.

It is evident therefore that the two series are conformable and that a transgression of the sea occurred over the slowly subsiding land surface. There is a gradual transition from fresh-water to marine conditions. There was apparently no difference in the kind of sediment brought down by the river, but, whereas previous deposition had been under fresh-water conditions in a large estuary with accompanying characteristic irregularity, the muds were now laid down under brackish to marine conditions. With increase of salinity of the water it was possible for a shallow water marine fauna to exist.

Description of Fossils.

Phylum: Brachiopoda.

Order: Atremata.

Genus: *Lingula* Bruguière.

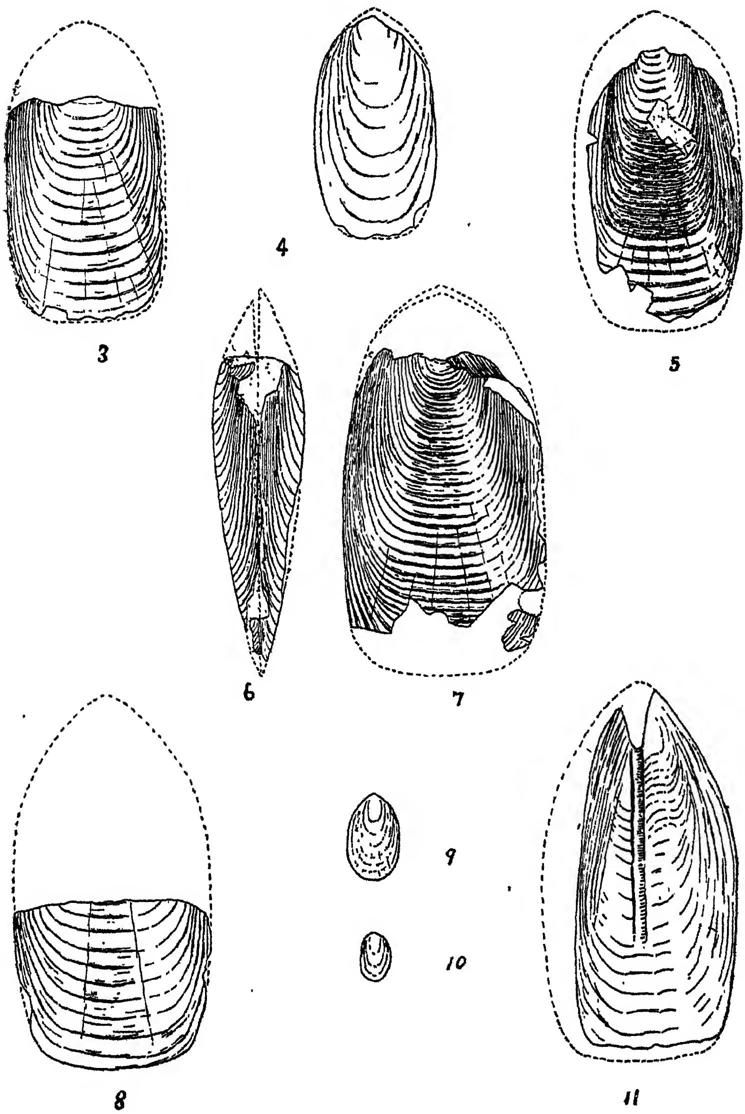
Lingula waikatoensis n. sp. (Figs. 3-14).

Holotype: See Figs. 6, 7 and 14.

Dimensions: Approximate length 26 mm.; breadth 14 mm.; ratio 1.85.

Locality: Stone drive, Main Rope Road, Renown Colliery, Waikokowai.

Shell oblong oval, the length not quite twice the breadth. From the point of maximum breadth the shell tapers slightly to the anterior margin which is formed on a slight curve of large radius, and has rounded corners. No median projection, such as often occurs in



Lingula waikatoensis n. sp. All ×2.

FIGS. 3, 5, 8.—Portions of shells.
FIG. 4. —External cast of partly grown shell.
FIGS. 6 & 7.—Holotype. (See Fig. 14).
FIGS. 9 & 10.—External casts of young ferns.
FIG. 11. —Internal cast of distorted shell, showing medial depression. (See Fig. 13).

[*W.H.A.P. del.*

Lingula, is present. Posteriorly the shell narrows more rapidly and is produced into an umbo which is probably blunt though no shell was found with the beak intact.

The exterior of the shell has usually a rounded median ridge or carination, high and narrow near the beak but diverging and flattening towards the anterior margin. According to Morse (1902, p. 321), from a study of living forms, this marked ridge especially in the small lingulids and *Glottidia* is due to warping and shrinkage of the soft tests on drying and "has no existence in nature." He stated that even in the larger and heavier shells, e.g., *L. anatina*, where a heavy deposit of lime renders the shell more rigid, "a region of the shell extending in a median line from the peduncular end is generally represented a little more arched than in nature." Johnston and Hirschfeld (1920, p. 56) state in regard to *L. hians*, a recent species, that "dried specimens became more or less distorted especially towards the umbonal end, where the valves contracted laterally in such a way that this portion of each became higher, narrower and more pointed than under natural conditions." Their proper shape was restored on immersion in warm water. It appears therefore that this ridge is a secondary feature and is more marked with the smaller and softer forms of lingulids.

The colour in the specimens collected varies from light brownish yellow or buff through dark amber to dark brown or nearly black. In the darker shells a distinct greenish tinge may be seen towards the centre of the valve. The largest shells are the thickest and the darkest; the young and small forms shown in Figs. 9 and 10, being a light buff to cream colour. Often two shades are present on the one shell marking lines of growth (see Fig. 13).

The shells are brittle, thin, smooth, glistening, and occasionally perforate. They appear to be composed mainly of chitinous material, but the number of specimens is insufficient to warrant the work of sectioning to determine the amount of calcium phosphate present.

Ridges due to increments of growth are well marked and were of assistance in reconstructing the original shape of each shell. As mentioned before, increase of the shell is sometimes accompanied by a change of colour. Radial striations are present near the anterior border.

Muscle impressions are not observable, but on one internal cast (Figs. 11 and 13) there is a well marked median depression which may represent the median septum in the dorsal valve of *Glottidia* (see Thomson 1927, Fig. 36b, p. 128).

Only single valves were found, with the exception of the specimen constituting the holotype. The shells are incomplete and more or less fragmental, and owing to shrinkage and movement of the enclosing muds they are often to some extent flattened and crushed. The shells of young lingulids are found with those of the mature forms, and are in general more complete. Examples of young shells are given in Figs. 4, 9 and 10. Small fragments of shells also occur scattered throughout the rock.

Comparison of this lingulid with other fossil lingulids has been difficult because no material and scanty literature are available here for such purposes.

Reference has been made to descriptions of fossil lingulids by Davidson (1874), Zittel (1900), Grabau and Shimer (1909), Hall (1847), Reeve (1841), Bittner (1890), and to descriptions of recent species by Blochmann (1892), Morse (1902), and Johnston and Hirschfeld (1920).

No specific affinities were found with any of the fossil lingulids described. With respect to the recent species Johnston and Hirschfeld (1920, p. 79) regard the ratio of length to breadth as constant for each species, and give the following ratios:—

L. hians Swains., 2.3 to 2.47.
L. murphiana King, 2.2 to 2.3.
L. anatina Lam., 2.2.
L. bancrofti Johns. and Hirsch., 2.0 to 2.1.
L. exusta Reeve, 2.2 to 2.5.
L. tumidula Reeve, 1.5 to 1.6.

From illustrations given by Morse (1902, Plate 40), the ratio for *Glottidia pyramidata* Dall is 2.7 to 3.

As far as it has been possible to determine from the fragmentary shells described in this paper their ratio varies from 1.85 to 1.87, which does not resemble that of any of the recent species quoted above. Schuchert (1911, p. 262) stated that "a survey of the geographic distribution of the inarticulate brachiopoda also shows that all the litoral and shallow water species are bound to warm waters, and that hardly any are common to two zoological provinces." During middle Tertiary times New Zealand must have been a separate zoological province, as it is at present, and therefore there were probably specific differences between the lingulids here and elsewhere. No recent lingulid is known in New Zealand waters and no other fossil lingulid is known either from New Zealand or from Australia. Comparison of types in this and neighbouring zoological provinces is thus impossible. The description of this newly discovered fossil form given above is sufficient to enable recognition of the species if found elsewhere. For the above reasons the creation of a new species is justified.

Associated Fossils.

Occurring with the lingulid were found *Cardium* (small), *Tellina, Dosinia,* and a small gastropod resembling *Cylichna* or *Bullinella.* In addition, one large fish scale was obtained from the Renown Colliery locality together with what appears to be portion of a fish bone.

The occurrence of *Cardium* is in keeping with the brackish and shallow water nature of the deposit, for according to Fischer (1887, p. 1035) it is an "animal marin, saumatre ou lacustre."

Some recent species of *Tellina* in New Zealand are found in mud flats at the mouths of rivers.

Tokunaga (1906, p. 69) recorded the occurrence of *Lingula hians* Swains., in a fossiliferous bed at Oji north of Tokyo, Japan. Associated with this *Lingula,* which was very scarce, were *inter alia* two species of *Cylichna,* six of *Tellina,* three of *Cardium* and a *Dosinia.* Indeterminable fragments of fish bones also occurred; a large number

of fossils was listed from Oji, deep water and shallow water types, and apparently further separation is needed. The age of the beds is probably Pleistocene. This occurrence, though not a parallel to the Lingula Claystone of the Waikato, is interesting as showing a similar association of genera.

ENVIRONMENTAL CONDITIONS.

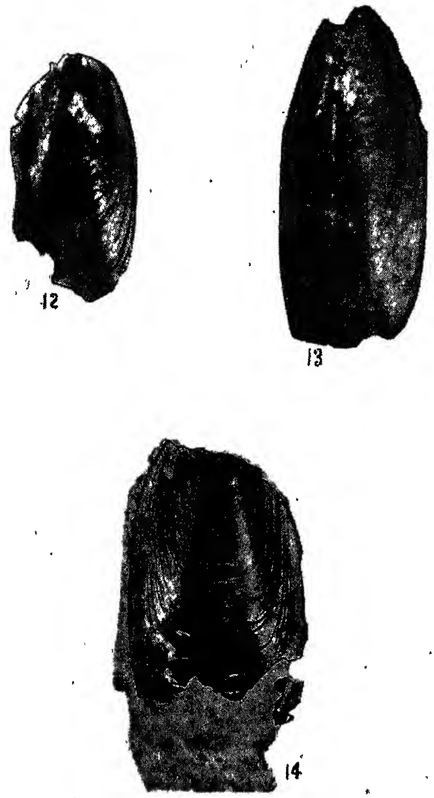
The environmental conditions of this fauna may be deduced from their known habits.

Morse (1902) stated that lingulids in general live in very shallow waters on a muddy or sandy bottom, and owing to their remarkable vitality, gradual elevation or subsidence of the coast line would in no way affect their condition. *Glottidia pyramidata* Dall was found living in great numbers at Beaufort Harbour, North Carolina, on shoals which are exposed at low tides (Morse 1902). *Lingula lepidula* lives in a few fathoms of water on a sandy bottom at Yenoshima, Japan (Morse, 1902). *L. anatina* is found at the mouth of the Takahashi River, which empties into the Shimabara Gulf, Japan, in a gravelly and muddy deposit just beyond low tide (Morse, 1902). *L. murphiana* is not uncommon in the sandy muds between tide marks in certain localities in Moreton Bay, South Queensland, and at the Philippines (Johnston and Hirschfeld, 1920, p. 59). *L. tumidula* is found in sandy mud at low water (Johnston and Hirschfeld, 1920, p. 51); *L. smaragdina* Adams from mud at 10 fathoms from Japan and the China Seas (*op. cit.*, p. 53); *L. hians* is common in mud flats at Noumea, and in the China Sea lives in mud or sandy clay at low water mark, its presence being indicated by the occurrence of oval orifices in the mud (*op. cit.*, p. 59). "The wide distribution of the species suggests that the larva has a fairly extended life and is able to adapt itself to rather wide limits of temperature, since the adult occurs in tropical, sub-tropical and warm temperate waters in the Eastern Pacific." A species, probably *L. hians*, was found "buried in a close unctuous mud two or three inches deep" from a muddy bay to the east of Evans Bay, near Cape York, North Queensland. "The fleshy or gelatinous pedicle which passed from between the beaks was five or six times as long as the shell and passed down into the mud, ending in a thickened knob. These pedicles did not appear to be attached to anything. On pulling at the shell a slight resistance was felt but not more than would be caused by the knob being drawn through the narrower hole in which the pedicle lies." (Jukes, fide Johnston and Hirschfeld 1920, p. 58).

L. exusta occurs in mud close to the edge of the beach sand at Dunk Island north of Rockingham Bay, North Queensland (Johnston and Hirschfeld, 1920, p. 65).

L. bancrofti (*op. cit.*, p. 67) is found in sheltered mud flats on the shores of Hervey Bay, Burnett Head, which are exposed at low tides.

Hayasaka (1922, p. 1) gives the depths of water in which recent species of *Lingula* occur as follows:—



Lingula waikatoensis n. sp.

All about twice natural size.
Fig. 12.—Portion of shell showing change in colour during growth. (See Fig. 5).
Fig. 13.—Internal cast showing median depression. (See Fig. 11).
Fig. 14.— Holotype. (See Fig. 7).

[*Royal Studios, photo.*

L. adamsi Dall, 7 fathoms.
L. affinis Hancock, 0-1 fathoms.
L. anatina Brug., 0-1 fathoms widely distributed.
L. jaspida Adams, 7 fathoms.
L. lepidula Adams, 10 fathoms.
L. smaragdina, Adams 10 fathoms.

Schuchert (1911) noted the great vitality of lingulids which he found growing on the tidal flats of Japan, where they are exposed for hours without injury. At high tide they are covered with three or four feet of water. He found further that lingulids lived in brackish water or water so foul with decomposing organic matter that all other shell fish were killed. He quoted Yatsu (1902) stating that the lingulids on little estuaries in certain bays in South Japan may be covered by sand and mud brought down by stream freshets, in which event the lingulids would continue to live by burrowing to the surface by means of their contractile and regenerative peduncle.

Schuchert observed that many species of *Lingula* occur in bays and estuaries indicating thereby that they prefer a habitat more or less freshened by fresh water.

"The immediate shore line, and often the estuarine bays and deltas, will be indicated especially by the large lingulids embedded in muds and sands with an otherwise sparse fauna." (Schuchert, 1911, p. 264).

Among recent species of inarticulate brachiopods he found that 24 live between high tide and a depth of 90 feet, and concluded that from the strand line to about 60 feet depth was characteristic of the litoral habits of *Lingula.*

During life the lingulids were able to crawl about slowly on the surface of the sediments or lie half buried in them (Morse, 1902). By means of their long peduncle, which with the Atremata is a burrowing and prehensile organ and not for permanent attachment to a given place as with all other brachiopods, they were able to draw themselves into the muds or force their way out when necessary. A secretion of mucous by the peduncle agglutinated particles of sand about the posterior end and by this means they are able temporarily to anchor themselves.

" On dying, the body (of *Glottidia*) protrudes from its burrow and rests at full length on the sand; it gradually turns black as a result of decomposition and the slightest jar causes the body to separate from the buried peduncle and float away." Morse (1902, p. 318). After death, therefore, the delicate and light shells are liable to be carried away by even the slightest current if sediment is being deposited too slowly to bury them in place.

As regards the fossil lingulids, Thomson (1927, p. 128) stated, "As the animal lives by preference on quite shallow sandy or muddy bottoms it is only exceptionally to be found fossil in rocks deposited at greater depths." According to Stevenson (1912, p. 518) "the inarticulate brachiopods have changed comparatively little in charac-

ter since their first appearance, and in all probability as little in their habits.'' On this fact he based his deductions as to the shallow water origin of the beds overlying coalfields in the Appalachian region where he found *Lingula* and *Orbiculoidea* (*Discina*) in the dark roof shale of the Middle Kittanning Coal Bed of Ohio, and in several of the roof shales in Kentucky.

Schuchert also (*op. cit.*) found that *Lingula* has endured since Ordovician times without change other than the superficial ones of form size and ornamentation.

Twenhofel (1926, p. 135) followed Schuchert in regarding *Lingula* and *Discina* as characteristic of shallow water from the strand line to about 60 feet. He stated that these two inarticulate forms were known to have lived on a muddy bottom as do some of the lingulids of to-day.

Summarising the significance of the habits of lingulids, Schuchert (*op. cit.*, p. 262) stated, "They are excellent guides as indicators of shore lines, and as such give clear guidance to the palaeogeography of any given time.''

Conclusions.

The conclusions that may be drawn from the occurrence of *Lingula waikatoensis* in the claystone overlying the coal measure series in the Waikato are as follows:—

1. There is clear evidence of the inception of marine or brackish water conditions following the fresh water coal measure claystones. This is confirmed by the stratigraphical succession.

2. The climate was warm-temperate to sub-tropical.

The geological history of this region subsequent to the accumulation of the vegetable debris now forming the coal seams is therefore one of a slowly subsiding land surface, in a large estuary of which fluviatile muds were deposited over the vegetal matter by the inflowing rivers. These muds are characteristically variable both in colour and in consistency and contain leaf remains and irregularly distribtued masses of coalfield vegetable matter. Continued subsidence permitted a transgression of the sea and in the shallow brackish and saline waters which now covered the original fresh water muds the fine sediment carried in by the rivers was more uniform, especially in colour. In this shallow water area, protected from wave action either by a long barrier beach characteristic of subsiding coastal plains or by its situation in a large bay or sheltered gulf, conditions were suitable for the existence of a fauna characterised particularly by lingulids. This fauna is the first evidence of marine conditions in the coal basin of the Lower Waikato district, and if its extent and distribution could be determined the palaeogeography of the land in Middle Tertiary times would be definitely fixed. Continued subsidence resulted in the deposition of the deeper water marine beds of the Whaingaroa and Te Kuiti series.

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Fossil Leaves from the Waikato District.

With a Description of the Coal Measure Series.

By W. H. A. Penseler, M.Sc., B.E., A.O.S.M.

[*Read before the Wellington Philosophical Society, 11th June, 1930; received by Editor, 13th June, 1930; issued separately, 18th November, 1930.*]

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Contents.

Introduction.

As a result of mining operations in the Pukemiro Collieries leaf remains were discovered by the writer in the claystone underlying the coal seam, and on subsequent search were found to be fairly commonly distributed in the shaly claystone which in many places forms the roof of the coal. Similar leaves were found in the other mines of the Waikato district. These leaf remains can rarely be observed at outcrops on account of weathering, and they can be obtained in a fresh condition only when, through the necessities of mining, "bottoms have to be lifted," or the roof "taken down," or in "stone drives," etc. Even then the rocks so disturbed do not invariably contain these fossils. Probably, during the years in which mining operations have been carried on in this district many fossil leaves have been encountered and specimens have been irrecoverably lost through lack of scientific interest on the part of the technical staff of the different colleries.

Assistance in the identifications of the fossil leaves collected was rendered by Mr. W. R. B. Oliver, M.Sc., Director of the Dominion Museum, Wellington, to whom the writer extends his thanks. Palaeobotany in New Zealand has been much neglected and therefore comparisons with other fossil leaves were difficult. In assigning a generic name to a leaf its resemblance to recent leaves was the deciding factor, especially because the leaves were all dicotyledonous.

The writer acknowledges his indebtedness to the Dominion Laboratory, Wellington, for the analyses on p. 460.

The leaves collected by the writer have been lodged with the palaeontological collections of the N.Z. Geological Survey, Wellington.

HISTORICAL ACCOUNT.

Hochstetter (1859), when describing the outcrop of coal at Kupakupa on the west bank of the Waikato River near Huntly, referred to the occurrence of fossil plants, principally dicotyledonous leaves, in the shale overlying the coal. He found no ferns accompanying the leaves. In 1864 and 1867 he stated that, of some fossil dicotyledonous leaves found in the coal measures near Drury, the following species had been determined by Unger:—

	Analogies.
Fagus ninnisiana Ung.	*F. procera* Pöppig from South Chile.
Loranthophyllum griselinia Ung.	*Loranthus forsterianus* Schult., and *Griselinia lucida* Forst., of the family Cornae, diffused throughout New Zealand.
Loranthophyllum dubium Ung.	*Loranthus longifolius* Deso.
Myrtifolium lingua Ung.	No analogy with other fossil leaves of plants of that day.
Phyllites purchasi Ung. *Phyllites ficoides* Ung. *Phyllites novae-zelandiae* Ung. *Phyllites laurinium* Ung.	Imperfectly preserved: genus indeterminate.

Unger (1864) described and illustrated these leaves, of which, however, *L. griselinia* is from the Bay of Islands and not from Drury. Unger's descriptions and illustrations will be considered later.

Hutton (1867) described the geological section at Kupakupa and found, overlying the coal, four feet of "dark blue shale containing leaves of dicotyledonous plants similar to those of Drury and Nelson." Later, Hutton (1870) mentioned that there were four or five varieties of these dicotyledonous leaves from Drury and Waikato.

Cox (1877) noted the dicotyledonous leaves in the sandstone roof on the coal seam at Kupakupa.

Park (1886) obtained a small collection of fossil plants from the fireclays at the Taupiri Coal Mine, but gave no description. This collection now forms part of the palaeontological collections of the New Zealand Geological Survey and consists of 18 specimens. On examination by the writer the leaf remains appeared to be similar to those collected and described later in this paper, but the carbonised leaf remains have peeled off the stone and have broken into small pieces so that they cannot now be identified with certainty. All that can be said about the collection is that the leaf remains are mixed with a great amount of fragmentary vegetal matter.

Later, Park (1899) when discussing the coals of New Zealand stated that "the Tertiary coals of New Zealand are the result of forest vegetation of long continued growth, among which dicotyledonous plants are well represented, including oak, myrtle, laurel, cypress, cycads and conifers. Remains of ferns are also abundant."

Possibly, part of this statement was based on the fossil plants found near Huntly.

Henderson and Grange (1926, p. 49) noted the occurrence of unidentifiable carbonised and fragmentary plant remains in the coal measures.

Excepting Unger's description, therefore, no detailed account of these fossil leaves has been published and their occurrence seems to have been neglected. It was Hector's intention, apparently, to publish an account of the fossil leaves of New Zealand, including those collected by Park, but this intention was never realised, although drawings of them had been made. There are no descriptions of these drawings and it is therefore, in the absence of the specimens, impossible to determine their origin.

Outline of Stratigraphy.

On a gently undulating, planed surface of folded Mesozoic greywackes, argillites, and indurated sandstones, a coal measure series of early Tertiary age was laid down. This series consists of brown and grey claystones, sometimes sandy, and from 80 to 300 feet thick. One to three thick seams of coal, and in places some thin seams, occur near the base of these rocks which are locally known as "fireclays."

Overlying the Coal Measure Series is the Whaingaroa Series of pale coloured claystone followed by bluish-green calcareous glauconitic sandstone and dark grey calcareous claystone containing a marine fauna. Following this is the Te Kuiti limestone of which only the basal members are present in this district.

The ages of these series are as follow:—

Shingle, sand, clays, etc., and swamp deposits		Pleistocene to Recent.
Limestone	Te Kuiti Series	
Grey claystone		
Greensand	Whaingaroa Series	Ototaran Stage, Oligocene
*Lingula claystone		
Claystones and Coal,	Coal Measure Series	
Greywackes, Argillites, etc.		Mesozoic

Note: The grouping and naming of the individual beds is a result of the writer's investigations, the series and their ages being quoted from Henderson (1929).

Coal Measure Series.

The rocks forming this series are dominantly argillaceous, and, though commonly referred to as fireclays, are better classified as claystones. In places where leaching by organic acids has taken place the claystones approach a true fireclay and are then used for brickmaking and pottery work, and for fire brick in gasworks. Analyses of some of these rocks (Henderson and Grange, 1926, pp. 87-90) are given in Table 1.

*See Penseler, 1930B.

TABLE 1.

ANALYSES OF CLAYSTONES.

	1	2	3	4	5	6	7	8
Silica, SiO_2	41.40	47.71	53.80	59.00	56.67	61.96	60.91	62.88
Alumina, Al_2O_3	39.40	29.95	31 80	26.20	24.28	23.87	23.33	22.22
Ferric oxide, Fe_2O_3 ...	1.60	0.98	1.76	2.20	1.60	1.07	2.44	2.20
Lime, Ca O	0.20	0.11	nil	nil	0.10	0.09	0.34	0.43
Magnesia, MgO	0.10	0.12	0.10	0.10	Trace	—	—	nil
Titanium dioxide TiO_2 ...	—	0.83	—	—	0.92	1.33	0.92	0.92
Potash, K_2O	0.50	0.22	0.40	0.10	0.48	0.43	0.39	0.36
Soda, Na_2O		0.10			0.39	0.28	0.21	0.23
Combined water and organic matter	16.80	11.99	12.14	12.40	7.76	9.37	9.17	8.29
Water at 100°C.	—	8.11	—	—	8.10	*2.08	*2.69	*2.48
	100.00	100.12	100.00	100.00	100.30	100.48	100.40	100.01

No. 1.—Fireclay, Waikato (probably Huntly, but precise locality not given). Twenty-seventh Ann. Rep. Col. Lab., 1904, p. 11.
No. 2.—Clay from weathered Mesozoic rock; Te Pake Road.
No. 3.—Fireclay, at least 4 ft. thick, below coal, main haulage-way, Taupiri Extended Mine. Fifty-second Ann. Rep. Dom. Lab., 1919, p. 22.
No. 4.—Fireclay, 10 ft. thick, below coal, Rotowaro Mine. Idem.
No. 5.—Fireclay, Waikato Extended Mine. Fifty-fifth Ann. Rep. Dom. Lab., 1922, p. 21.
No. 6.—Fireclay, Pukemiro Junction Mine. Fifty-ninth Ann. Rep. Dom. Lab., 1925, p. 29.
No. 7.—Fireclay, 15 ft. thick, works of Huntly Brick and Tile Company. Fifty-sixth Ann. Rep. Dom. Lab., 1923, p. 17.
No. 8.—Fireclay, below coal, Rotowaro Mine. Fifty-sixth Ann. Rep. Dom. Lab., 1923, p. 18.

The theoretical mineral compositions of the "dry" clays, Nos. 5, 6, 7 and 8 have been calculated as follow:—

	5	6	7	8
Felspar	7.19	5.41	5 96	6.32
Quartz	27.78	32,14	32.38	35.82
Limonite	1.94	1.28	2.92	2 64
Clay substance and combined water	63.09	58.67	58.74	55.22
Minor constituents	—	2.50	—	—
	100.00	100.00	100.00	100.00

The claystones of the Coal Measure Series are often indistinguishable from the weathered argillites on the surface of the underlying unconformable Mesozoic rocks. As shown by some bore-hole logs the one grades insensibly into the other and it is only when

*Water at 105°C.

the basement rock is hard and unweathered (e.g. greywacke)) that the driller can tell with certainty that the "fireclays" have given place to the "understone."

The Coal Measure Claystones vary in thickness from 80 to 300 feet and contain near their base one to three thick seams of coal and often some minor seams of less extent. The Coal Measure Series is naturally thickest in the deepest portion of the original basin.

The origin of this series as a freshwater estuarine deposit may be stated now instead of as a conclusion. The logical sequence is thus to some extent inverted, but by keeping this conclusion in mind the significance of the features to be described will be realised better.

The main characteristic of the series is its variability both lithologically and in colour. Though in the main argillaceous, sandy patches are encountered grading into normal claystone vertically and laterally. The base of the series is usually sandy, and in some districts, e.g., Glen Afton, contains rounded pebbles of hardened clay, quartz, sandstone, etc., up to 1" in diameter embedded in fine claystone (Figs. 1 and 2). Coarse conglomerates or gravels are not found. Small, shaly, i.e., laminated, beds are common, but bedding on a large scale is shown only by the succession of beds of different colour, by dark coloured carbonaceous beds grading for a few inches into dirty coal, and by the occurrence of nodular bands of spathic iron ore. In hand specimens the typical claystone shows no bedding or lamination and appears homogeneous. The records of boreholes in the Waikato district show very well the change from place to place of the series, more especially of the beds overlying the coal seam or seams. This change is due to the lenticularity of the different beds in the series.

The colour of the claystones varies from dark grey for the carbonaceous shaly bands through dark brown, brownish-yellow, and light brownish grey to grey. The last named colour predominates and indicates reduction by decaying organic matter of most of the iron compounds, which have been removed in solution. This reduction of iron is due also to moist conditions in a warm temperate or subtropical region with plentiful rainfall where sediments are deposited under water or on damp, ill drained flats (Twenhofel, 1926, p. 547). The layers of fine, brownish-yellow claystone are a result of floods in the estuary when an increased quantity of water carrying yellowish mud in suspension overspread the river flats, scouring out previous deposits in the main channels and depositing the fine yellow muds in the quieter areas.

The claystones weather to a soft, sticky, yellow clay which obscures most outcrops and obliterates differences between successive beds. Underground, contact with mine air causes fretting and spalling off. The joints become loosened and the rock breaks up, and this necessitates timbering in those sections of the mines which have a claystone roof or sides.

During consolidation the sediments settled and shrank and, as the original site of deposition was undulating, differential settling would modify the positions of successive strata, and differential loading would cause an adjustment of the sediments to the pressure

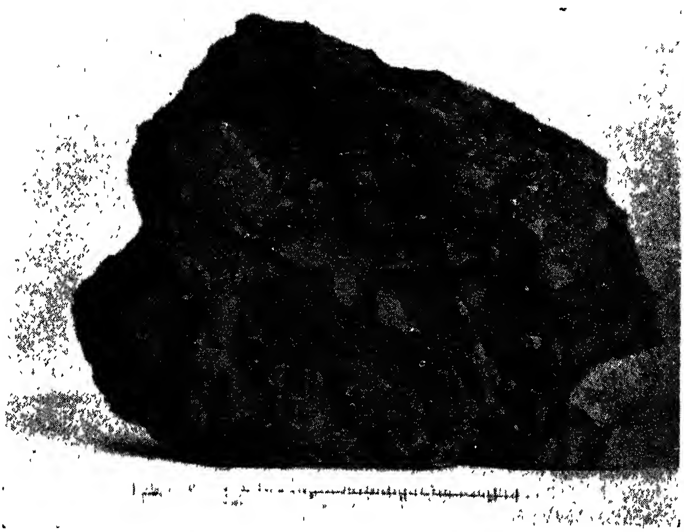


Fig. 1.—Conglomerate from near base of Coal Measure Series, Glen Afton.

Fig. 2.—Intraformational conglomerate from Coal Measure Series, Glen Afton.

Face p. 456.

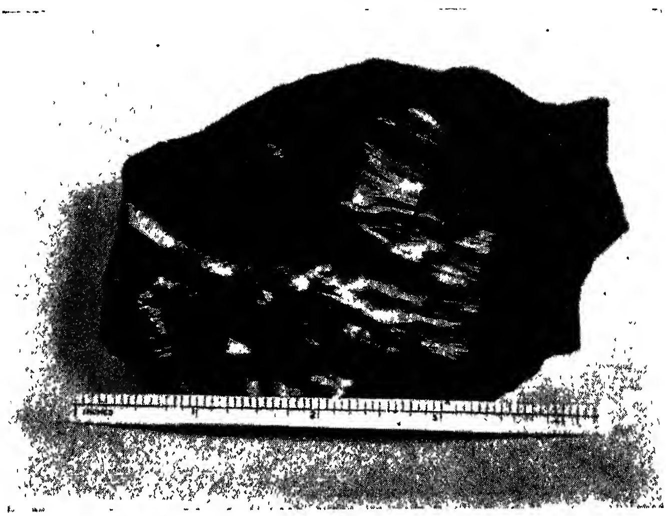


Fig. 3.—Polished surface from joint face of a claystone block.

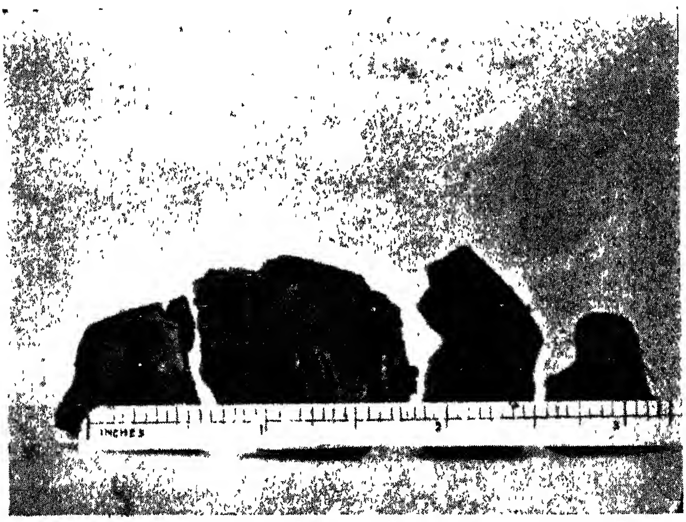
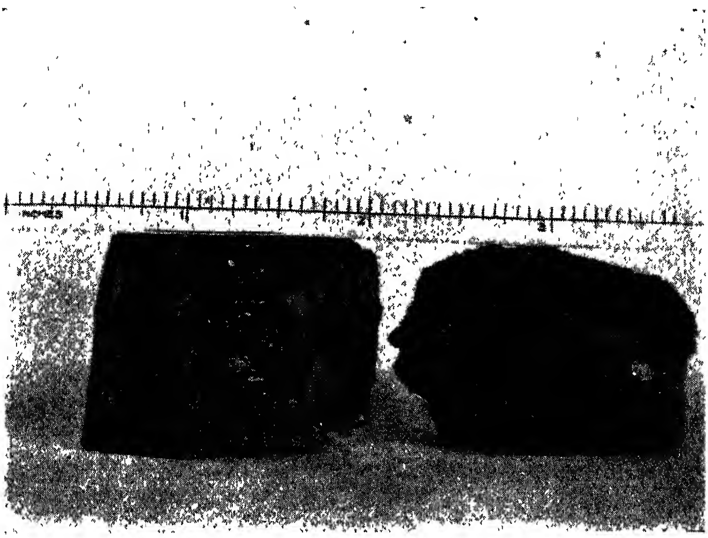
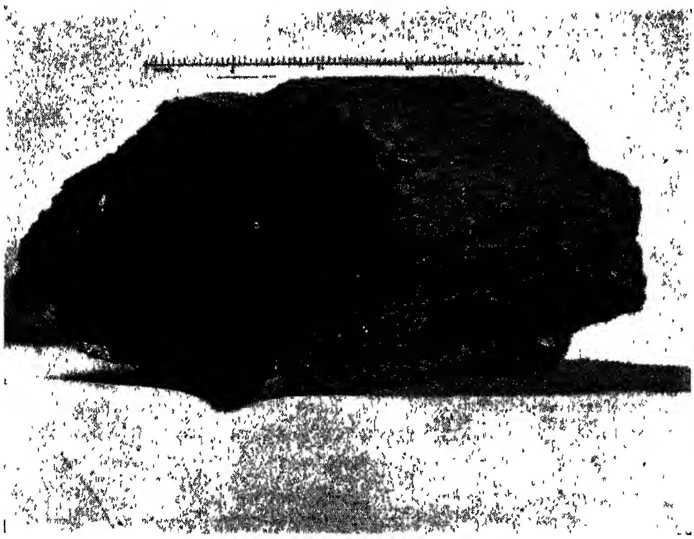


Fig. 4.—Lumps of fossil resin from Coal Measure Series.





Figs. 5 & 6.—Coalified plant remains occurring in claystones.

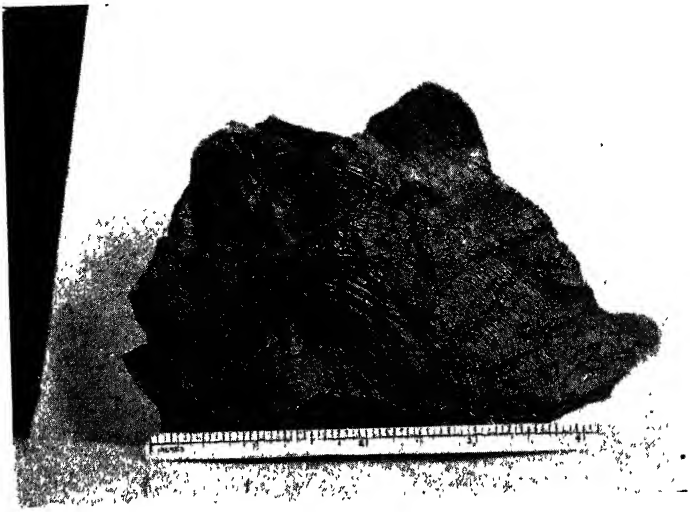


Fig. 7.—Coalified Fungus.

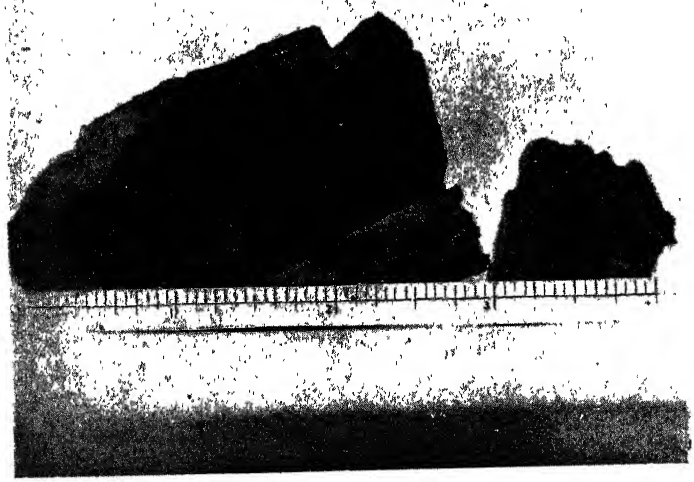


Fig. 8.—Coalified wood from claystones showing "bark."

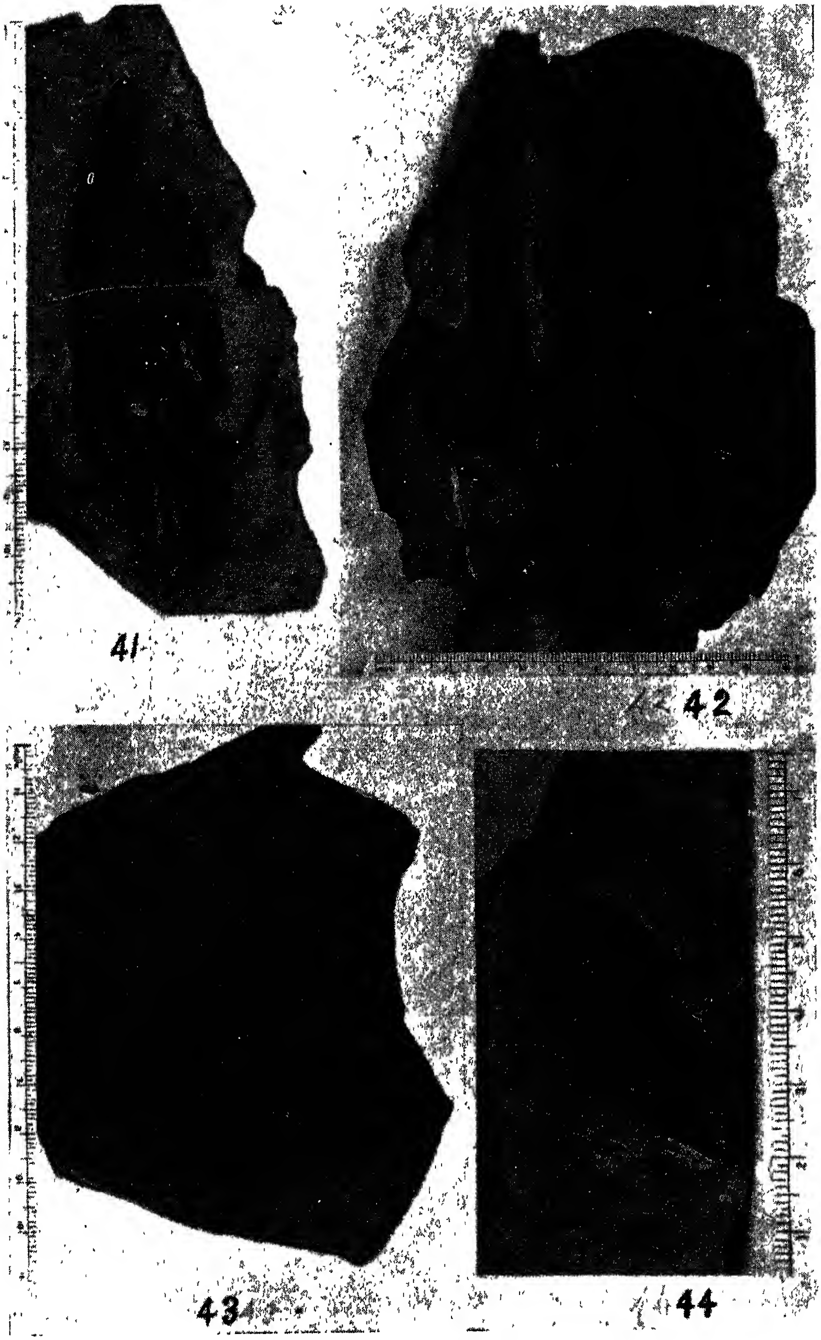


FIG. 41.—*Cinnamomum waikatoensis* n. sp.
FIG. 42.—*Pisonia oliveri* n. sp.
FIG. 43.—*Beilschmiedia tarairoides* n. sp.
FIG. 44.—*Cassia pluvialis* n. sp.

imposed. On a large scale the effects would be variable and would in general induce lenticularity of the strata, but on a small scale the result is comparable with the cleat in the coal. Settling or shrinkage in the claystones, which may amount to 20 to 50 per cent. or more (Twenhofel, 1926, p. 526) results in a large number of small block faults each block rounded more or less vertically by polished faces (Fig. 3). The blocks may be a few inches square and up to a foot or so long—the thickness of the particular bed—or may be, as is more usual, a few feet square. In the former instance, that of a thin layer broken up by many inclined fractures, the effect may be due to compression and differential movement between the beds, and may thus be regarded as a form of fracture cleavage (Leith, 1923, pp. 148-158).

The larger and irregularly spaced joints or "faults" in a thick bed stand in various directions and attitudes. They may intersect, but commonly one joint either dies out before reaching another, or is cut off by another joint crossing it at an angle. Such joints die out vertically or merge into small monoclines. Leith (1923, p. 33), referring to joints related to the contraction of a crystallising and cooling mass of lava, said that "similarly, joints may be very abundant in flat-lying, partially consolidated beds of sediments, which plainly have not been disturbed by great exterior forces. One of the causes in this case is doubtless the change in volume incidental to the drying and settling of the beds. Mud cracks are one manifestation of this process. Joints formed in this manner are likely to be limited to particular beds and may die out above or below; there may be evidence that jointing in a given bed was complete before the next layer of sediment was deposited. They are likely to be especially abundant near the contacts of different beds or formations (a fact often noted by well-drillers in search of water)." This type of local tensional jointing he said (*op. cit.*, p. 50) "is developed by the drying out of a sediment, resulting in the formation of mud cracks and of shrinkage cracks on a large scale. The joints so formed lack regularity and persistence, vertically and horizontally."

It is evident therefore that the irregular jointing observed in the coal measure claystones is a result of the settling and shrinkage, including effects due to slumping in the original sediments.

The blocky nature of the claystones, combined with their property of flaking and loosening on exposure to the damp mine air, is a source of danger underground. A claystone roof is incapable of supporting itself and requires timbering.

The bands of iron ore are commonly in the form of nodules irregularly spaced and often up to 4 feet thick. They occur below, between and above the different seams and are the result of precipitation of iron from iron bearing solutions in the presence of decaying organic matter which, by providing excess of $C\,O_2$, causes precipitation in the form of carbonate. Twenhofel (1926, p. 331) considers that iron sediments are deposited usually in quiet waters, e.g., bogs, marshes, lakes, lagoons, and the sea, and are also precipitated where iron bearing solutions issue from the ground.

Similar views are held also by Clarke (1924, pp. 536-538). With regard to the concretionary type the iron may be brought in as ferrous bicarbonate solution from which, on escape of excess CO_2 and under conditions which do not allow of its replacement by oxygen, iron carbonate is precipitated (Twenhofel, *op. cit.*). Such conditions, according to this authority, obtain in marshes, shallow waters of the sea, lake coasts, and river flood plains where the growing vegetation extracts the CO_2 from the water and the decay of vegetation uses up the oxygen. Further, any iron precipitated as hydroxide might be altered to the carbonate by decaying organic matter. The presence of these concretionary masses of iron ore in the Coal Measure Series indicates, therefore, shallow water conditions such as would obtain in river flats in an estuary where the iron leached from the clays and sediments is precipitated on reaching the surface. There must have been excess CO_2 present from the abundant decaying vegetal matter in these sediments to prevent precipitation in the form of hydrated oxide. The iron ore bands occur at no definite horizon, but though horizontally bedded are irregularly spaced, and were therefore determined by local conditions at each place. An analysis of one sample is as follows: (from 56th Ann. Rep. Dom. Lab., N.Z., 1923, p. 24, quoted by Henderson and Grange, 1926, p. 96).

SiO_2	15.15
Al_2O_3	4.29
Fe_2O_3	0.54
FeO	41.48
MgO	1.78
CaO	2.96
K_2O	0.19
Na_2O	Nil
Water lost at 105°C.	2.12
Water lost above 105°C.	0.56
CO_2	29.10
TiO_2	0.24
P_2O_5	0.36
MnO	1.11
	99.88

As shown by this analysis the deposits are impure, as would be expected where sedimentary material is abundant.

Fossils of the Coal Measures.

A fossil fauna is absent.

Lumps of fossil resin similar to those occurring in the coal and named *Ambrite* by Hochstetter (1867) are common in the claystone (see Fig. 4). They have been observed so far only in the vicinity of the coal seam or seams, but this may possibly be owing to the lack of facilities for examining the remainder of the series. Hochstetter's (1867, p. 79) description is still applicable, and according to him the resin is transparent, brittle, and has a

glossy conchoidal fracture. In colour it is bright yellow to dark brown. It is easily ignited and burns with a steady fast-sooting flame with a bituminous rather than aromatic smell. He thought that the resin originated from a coniferous tree related to the present Kauri pine, and gave the following analysis:—

Carbon	76.65
Hydrogen	10.38
Oxygen	12.78
Ash	0.19
	100.00

which is equivalent to the formula $C_8 H_{13} O$.

Its hardness was 2, and specific gravity 1.034.

Analyses of other fossil resins with which this is comparable are given by Moore (1922, pp. 102-104), and the amber mined from Tertiary rocks on the shore of the Baltic Sea in East Prussia is described by Prockat (1930).

The low specific gravity of the resin would enable it to be readily transported by even slight currents, but any argument based on its present properties is unsafe because of the alteration it has undergone by hardening, loss of volatile matter, etc., since it was deposited. When a lump of resin occurs in a shaly layer the laminae are bent round it and it seems reasonable to suppose that it was drifted into secluded backwaters where it became entombed by the covering muds. Where the current was stronger the resin would be carried out to sea.

The resin in the claystones and that in the coal differ in origin to the extent that the former was allochthonous and the latter autochthonous, although both might have been derived from the same species of tree.

On exposure to the weather the resin becomes opaque and waxy looking.

The presence of the resin may be taken as evidence of the occurrence of coniferous trees in the flora of that time.

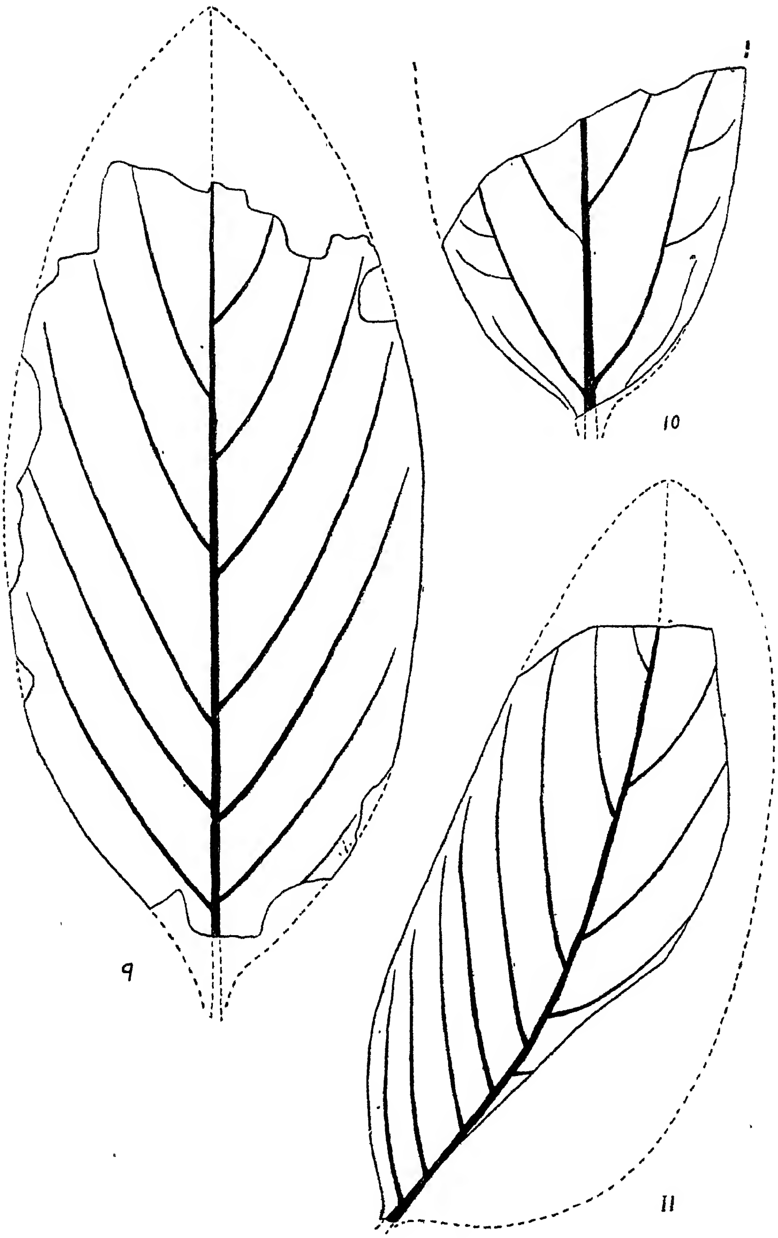
Fragmentary coalified plant remains (see Figs. 5 and 6) are of common occurrence and vary in size from small pieces, which represent twigs, up to large masses 6 feet or more long and 2 feet broad. The larger remains are usually more or less flattened and all have a black colour and a shining lustre. Smaller branching remains resembling roots also occur, and what appears to be a coalified fungus is shown in Fig. 7. One fragment had the "bark" still adhering (Fig. 8). These coalified plant remains are homogeneous, i.e., not laminated like the coal, and on account of their friability only small portions can be preserved as specimens. They occur in any part of the claystones and often are embedded partly in one variety of "fireclay' and partly in another. They represent fragments of plants that have been drifted in by the rivers which deposited the muds around them when they became stranded. Their analogy with the strips of "bright coal" in the seam (see Penseler, 1930A) is shown by the following analyses:—

	Bright Coal	Coalified fragment in fireclay above seam	Coalified fragment in fireclay below seam	Normal Coal
Water	22.94	18.49	20.14	15.34
Volatile Matter	28.22	27.79	28.68	35.88
Fixed Carbon	47.79	49.46	48.84	46.22
Ash	1 05	4.26	2.34	2 56
	100.00	100.00	100.00	100.00
Sulphur	0 26	0.53	0.48	0.30
B. Th. U.	9950	9734	9939	10802
On a dry ash-free basis:				
Volatile Matter	37.1	36.0	37.0	43 7
Fixed Carbon	62.9	64.0	63.0	56 3
	100.0	100.0	100 0	100.0
B. Th. U.	13090	12600	12820	13160

It will be seen from these analyses that the coalified remains are similar in analysis to the bright coal and are higher in water and fixed carbon and lower in volatile matter than normal coal.

The bright strips in the coal represent unmacerated fragments of wood in the original vegetable mass, and because the coalified remains found in the claystones are clearly derived from fragments of wood the above results were therefore to be expected. The point of interest, however, is that the wood in the form of logs buried in the clays has in the course of time been changed into "coal" similar to that formed from the remains of small pieces of wood in the peaty deposit now forming the coal seam proper. The latter are what was left when the general process of maceration and bacterial decay was suppressed by the smothering action of overlying material and by the probable development of toxic conditions in the peaty mass, and it may be concluded that the logs buried in the fireclays had not been subjected to any process involving maceration but had undergone bacterial decay. Heat and pressure in addition were responsible for the change from wood to coalified material.

Where the normal claystone changes to a laminated shaly clay, dark grey in colour, it often includes very thin streaks of bright coaly matter and on splitting these dark coloured laminated clays leaf remains are found. After splitting a fragment of shale containing a leaf, apparently two leaves are obtained due to separation of the leaf along the centre of the lamina. The state of preservation of the leaves depends on several factors. If the enclosing material is at all coarse grained (comparatively speaking) the leaves may be broken and fragmental, or impressions only may be left owing to opportunities for access of air and water. If the shale during the extensive shrinking which occurred in the coal and in the muds



FIGS. 9-11.—*Cinnamomum waikatoensis* n. sp. × 1.
From Coal Measure Claystones, Pukemiro Colliery.

[*W.H.A.P., del.*

was subjected to pressure resulting in lateral movement the surfaces and outlines of the leaves are blurred. It is only when the enclosing material is sufficiently fine grained and has not been distorted that favourable conditions obtain. Another important point is that leaves which have been transported by muddy water for some distance become bruised, torn, and fragmental, but those deposited in sheltered backwaters after very little transportation are more likely to be preserved whole. Fragmental leaves are often associated with much general vegetal debris such as portions of bark, broken twigs, branches, etc., as in Park's collection referred to previously.

The best preserved specimens were obtained from a dark grey shaly layer, a few inches thick, occurring in a light grey, rather sandy claystone about 6 feet below the base of the coal seam in the West Drive of the Pukemiro Colliery. The leaves, though not perfectly preserved in all detail, are much better than those collected at other places. They are all black in colour and occur horizontally bedded in this thin layer. Less well preserved and poorly preserved leaves were found in many places where a dark grey, shaly clay forms the roof of the coal seam, but in most instances prolonged contact with the mine air had caused the leaves to peel and scale off. This property of scaling has to be guarded against in specimens, which also have a marked tendency to break up into small rectangular pieces by a series of fine joints at right angles to each other.

On account of the weathering of the claystones into a sticky yellow clay, outcrops of the Coal Measure Series are disappointing to the collector. Any contained plant remains are usually broken up or obliterated, and even in sandy and shaly beds, which weather differently, plant remains quickly disintegrate.

The fossil leaves thus differ from the fragments of fossil "wood" described before in that the former are bedded and the latter irregularly distributed. No leaves have been observed joined to twigs in the form of sprays, and no leaves have been observed in conjunction with the masses of coalified wood.

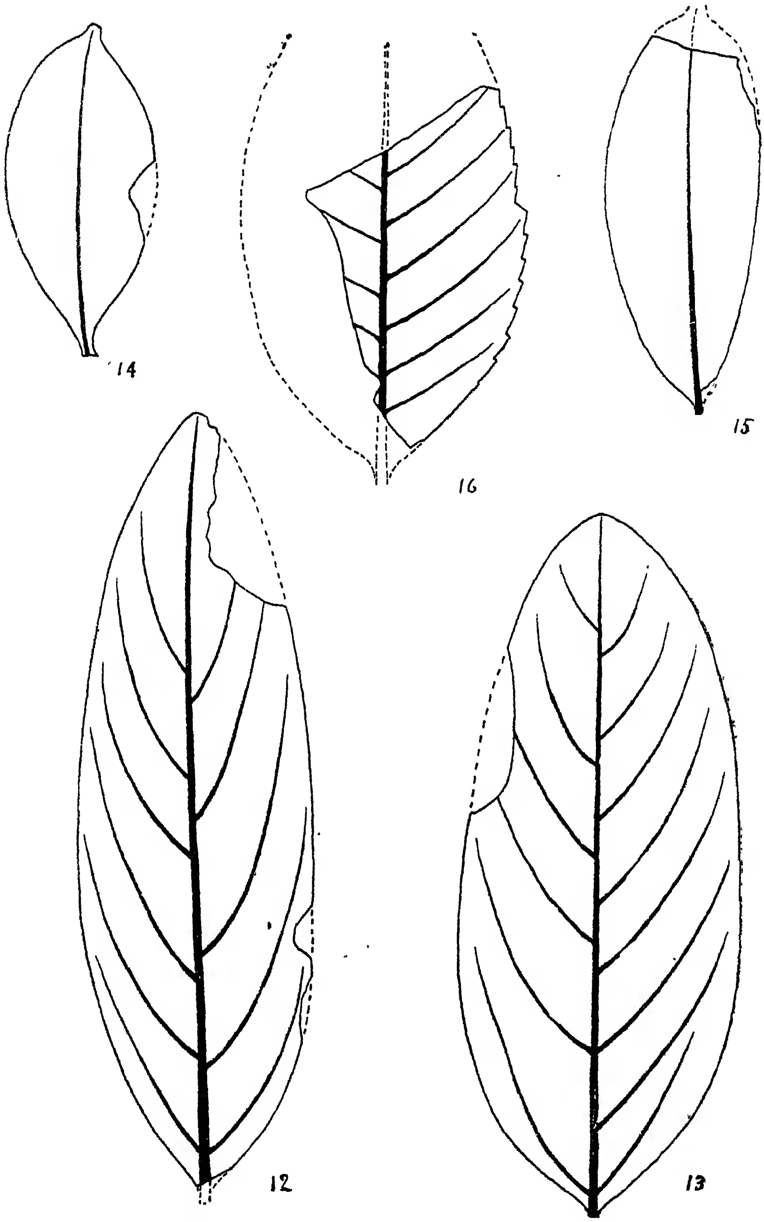
Fossil Leaves.

a. *Description.*

Cinnamomum waikatoensis n. sp. Figs. 9 to 13, and 41.

Holotype: Figs. 12 and 41.

Leaf oblong-elliptic, the apex slightly more acute than the base. Margin entire. Midrib well marked; secondaries alternate or sub-opposite, 6 to 8 on either side of the midrib, arising at regular intervals at an angle of about 45° and gently curving forwards and becoming obsolete near the margin; they are prominent and almost parallel. Tertiary veins, shown on Fig. 10, branch towards the margin, arising from the secondary veins at an angle of about 60° and curving forwards. On this specimen also a pair of small veins, probably tertiary, are seen near the base of the leaf.



FIGS. 12, 13.—*Cinnamomum waikatoensis* n. sp. × 1.
From Coal Measure Claystones, Pukemiro Colliery.

FIGS. 14, 15.—*Cassia pluvialis* n. sp. × 1.
From Coal Measure Claystones, Renown Colliery, Waikokowai.

FIG. 16.—*Fagus ninnisiana* Ung., × 1.
From Coal Measure Claystones, Pukemiro Colliery.

[*W.H.A.P.*, *del.*

Dimensions of laminae: 94 × 38 mm. (Fig. 13), 105 × 32 mm. (Figs. 12 and 41), 135 × 58 mm. (Fig 9), 117 × 45 mm. (Fig. 11).

This is the most commonly occurring leaf observed by the writer. It has been placed in the genus *Cinnamomum* because of the occurrence of two well marked opposite secondary veins at the base; and in order to give some means of identification to the leaf the specific name "*waikatoensis*" has been assigned to it. No form resembling this was collected by Hochstetter or described by Unger, and it has been impossible to find definite relationships with any modern genus in New Zealand. (Cf. *C. intermedium*, Ettingshausen, 1887, Taf. 4, Fig. 20).

Cassia pluvialis, n sp. Figs. 14, 15, and 44.

Holotype: Figs. 14, 44.

Leaf elliptic, widest in the middle and tapering towards either end. Base acute, apex produced into a rounded protuberance or drip point. Margin entire; midrib prominent. Secondary venation not observable.

Dimensions: 44 × 20 mm. (Fig. 14), 55 × 21 mm. (Fig. 15).

No leaf like this has been found among the living New Zealand flora, but it bears some resemblance to *C. pseudophaseolites* (Ettingshausen, 1887, Taf. 4, Fig. 6) from Shag Point and Murderer's Creek, the apices of which are missing or turned over and buried in the rock. The apices of *C. pluvialis* were bent over into the claystone and were discovered only by carefully picking out the covering rock.

Fagus ninnisiana, Ung. Fig. 16; see also Figs. 24 to 32.

A fragment without either base or apex, and showing a portion of one side only. Leaf apparently broadly elliptical. Margin serrate. Secondary veins arise regularly from midrib at an angle of about 60°, and terminate in the indentations within the marginal teeth.

Distance from midrib to margin, 19 mm.

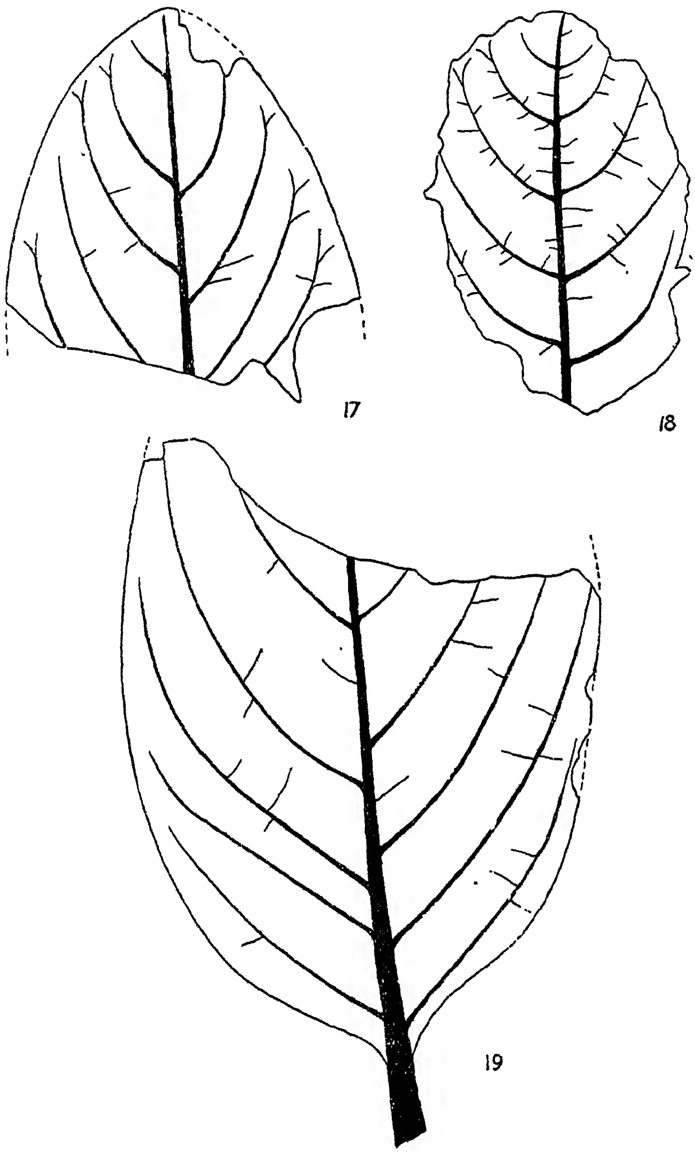
Estimated size of leaf, 72 × 38 mm.

This leaf is similar to those collected by Hochstetter from beds of about the same age at Drury and classed as *F. ninnisiana* by Unger (Figs. 24-32), and for the want of better specimens has been taken as belonging to the same species.

Unger compared *F. ninnisiana* with *F. obliqua* Mirb. and with *F. procera* Pöpp., recent species from Chile, which vary not only in size and shape but also in the marginal teeth exactly as do the fossil leaves. The longer petiole in the fossil leaves (Figs. 24 and 25) may be due to especially strong root force, although in other cases (Figs. 28 and 31) the size is not abnormal.

"It is remarkable that a plant form with its related kinds, which occurs in South Chile, Patagonia, Tasmania, and New Zealand, appears also in the Tertiary flora of these countries as well as in the Tertiary flora of the Northern Hemisphere. This may be an indication that the stock of *Fagus* originated in and spread readily from the Southern Hemisphere. What is particularly remarkable is that the large leaved kinds of this genus, with the folded bud

position of the leaves, as also the small leaved kinds with mostly leather-like leaves, are represented in the Tertiary flora, while New Zealand at present possesses only the latter kind." *F. ninnisiana* occurs also at Shag Point, Otago, and was described by Ettingshausen (1887, p. 24, and Taf. 4, Fig. 1; 1890, p. 270, and Pl. 27, Fig. 1).



FIGS. 17-19.—*Beilschmiedia tarairoides* n. sp. × 1.
From Coal Measure Claystones, Pukemiro Colliery.
[*W.H.A.P., del.*

Beilschmiedia tarairoides, n. sp. Figs. 17 to 19, and 43.

Holotype: Figs. 19 and 43.

Leaf broadly elliptic, margin entire. Midrib broad, prominent and prolonged into a thick petiole. Secondaries alternate or sub-opposite, arising at rather wide intervals at an angle of about 50° and arching forwards. They terminate near the margin and nearly parallel to it, and sometimes bifurcate at their extremities. Tertiary veins cross between the secondaries and nearly at right angles to them.

Breadth of largest leaf (Fig. 19) is 65 mm. The most similar leaf among the existing New Zealand flora is that of *Beilschmiedia tarairi,* and accordingly the fossil form has been given the specific name *tarairoides.*

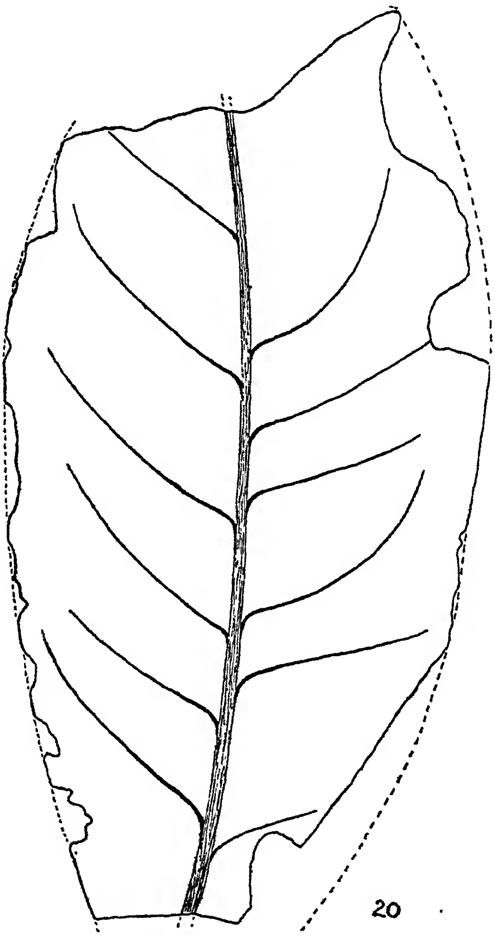


FIG. 20.—*Pisonia purchasi* (Ung.) × 1.
From Coal Measure Claystones, Pukemiro Colliery.
[*W.H.A.P., del.*

Pisonia purchasi (Ung). Fig. 20 and cf. Fig. 36.

A fragment of a large leaf without either base or apex. Leaf oblong elliptic. Margin imperfectly preserved, but apparently entire. Midrib well marked, and in this specimen, which shows the under surface of the leaf, is characteristically ribbed longitudinally. Secondary veins branch from the midrib at irregular intervals and are not always parallel. They leave the midrib at an acute angle but soon bend round to an angle of 65° to 70° and near the margin curve forwards again. Tertiary venation not observable. Maximum width of leaf 68 mm.

Unger (1864, p. 11) described a small fragment (Fig. 36) of a large leaf under the name *Phyllites purchasi*, which could not be compared with leaves of living or fossil plants. Comparison of

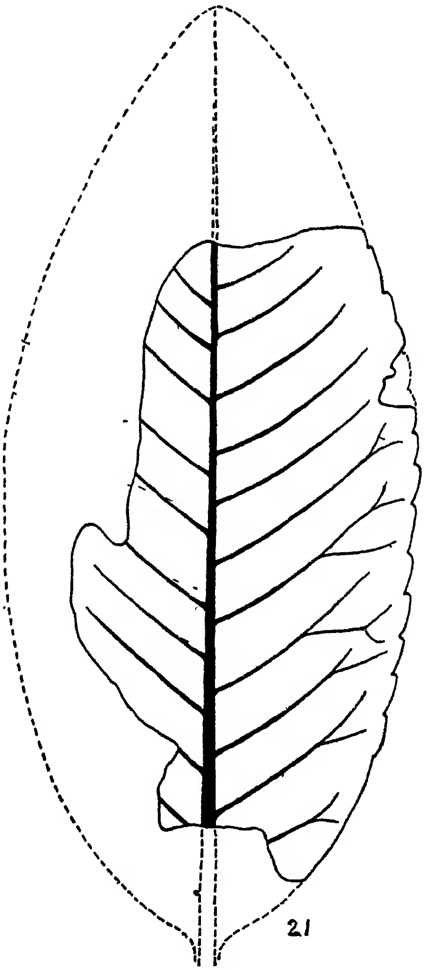


FIG. 21.—*Pisonia oliveri* n. sp. × ½.
From Coal Measure Claystones, Pukemiro Colliery.
[*W.H.A.P., del.*

Figs. 20 and 36 shows that these fragments are probably of the same kind. Moreover, the larger fragment collected by the writer is almost identical with leaves of the recent *Pisonia brunoniana* now living in North Auckland. The fossil leaves are accordingly placed in this genus and Unger's specific name retained.

Pisonia oliveri n. sp. Figs. 21 and 42, Holotype.

A fragment of a large leaf without base and apex. Leaf oblong elliptic, the apex probably slightly more acute than the base. Margin widely crenate. Midrib well marked. Secondaries alternate, parellel, branching from midrib at an angle of about 65° and sometimes bifurcating once and occasionally twice near the margin.

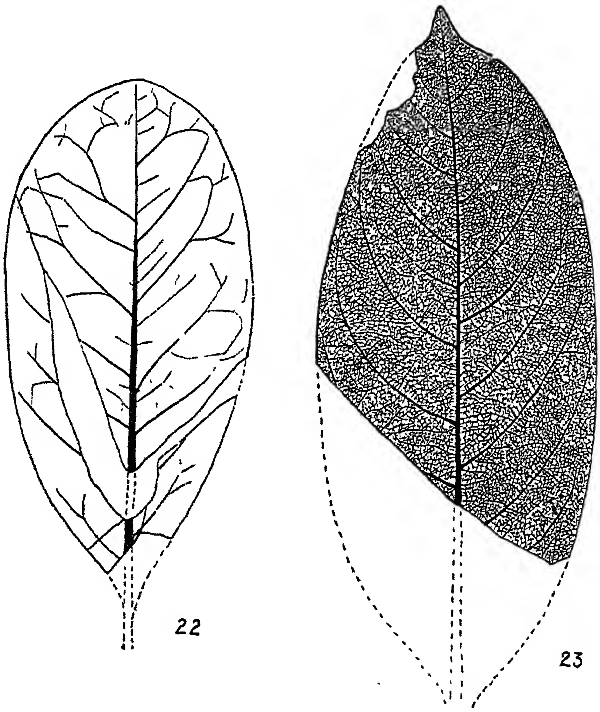


FIG. 22.—*Coprosma pseudoretusa* n. sp. × 1.
FIG. 23.—*Geniostoma apiculata* n. sp. × 1.
From Coal Measure Claystones, Pukemiro Colliery.
[*W.H.A.P.*, *del.*

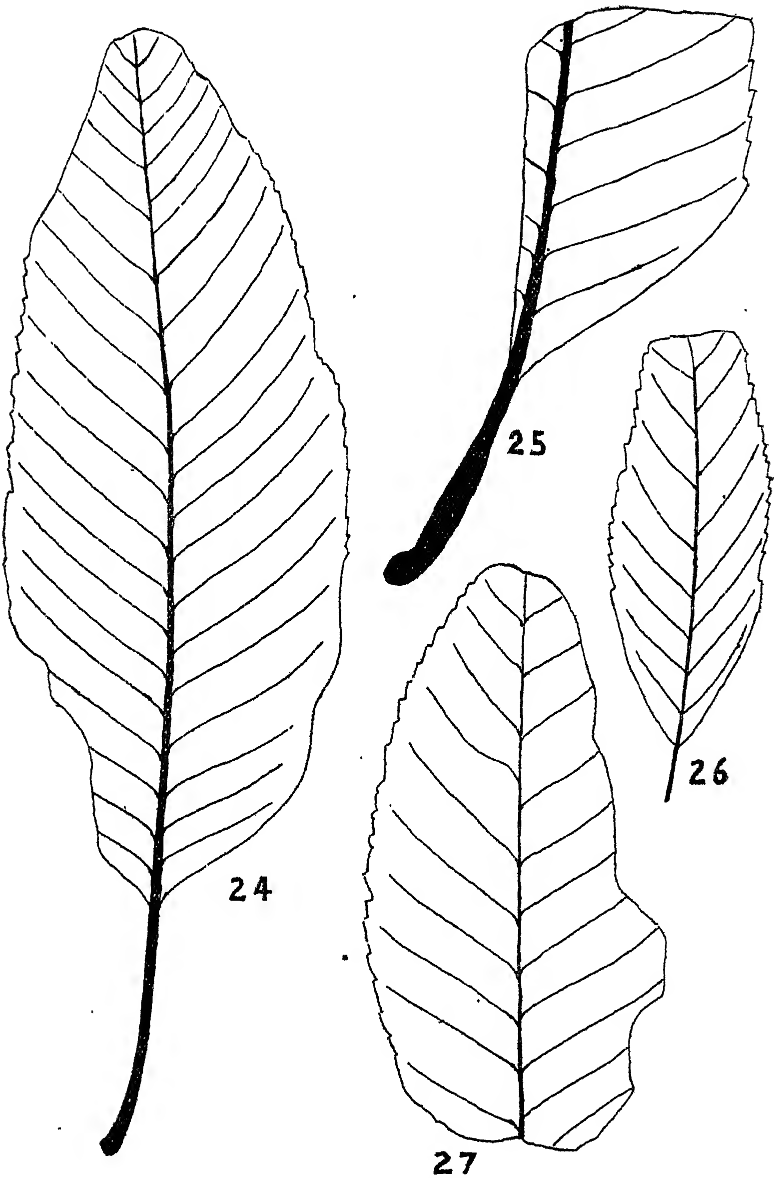
Estimated dimensions, 255 × 112 mm.

This leaf differs specifically from *P. purchasi* (Ung.) in the secondary venation and in the margin but it still has strong affinities with the genus Pisonia.

Coprosma pseudoretusa n. sp. Fig. 22, Holotype.

Leaf obovate. Margin entire. Secondary veins are alternate, straight and parallel, and branch from midrib at an angle of 45° to

50°. They anastomose near the margin and the tertiary venation, which is partly preserved, probably consists of a coarse network joining the secondaries. Dimensions, 75 × 34 mm. This leaf is very similar to the recent *C. retusa.*



FIGS. 24-27.—*Fagus ninnisiana* Ung. × 1.

From Mr. Pollock's Spring Hill Shaft near Drury, in a firm ferruginous sandstone of a fine grain and a brown colour.

[*After Unger.*

Geniostoma apiculata n. sp. Fig. 23, Holotype.

Leaf oblong elliptic; apex produced into a blunt point. Margin entire. Midrib and secondary veins well marked, the latter alternate, parallel and curving regularly forwards. The tertiary venation on this leaf is remarkably well preserved and consists of a fine network into which the ends of the secondary veins merge.

Dimensions, 95 (estimated) $\times$ 39 mm.

The following leaves collected by Hochstetter, were not found by the writer in the Coal Measure Series of the Waikato district, but their occurrence near Drury in beds of approximately the same age justifies their mention in this paper. Most of the leaves are so fiagmental that comparison with existing forms would be without benefit because of the probable inaccuracy involved.

Loranthophyllum dubium Ung. Figs. 33 and 34.

This leaf was named from its similarity to *L. griselinia* Ung. (1864, pp. 8-9, Taf. 3, Fig. 13) and to *Loranthus longifolius* Deso. A remnant of a stem (Fig. 31) from the same locality shows the original opposite positions of the leaves and the protruding leaf cushions such as occur also on the stem of *L. longifolius* (Fig. 32).

Myrtifolium lingua Ung. Fig. 37.

Unger found no resemblance to this well preserved leaf among either fossil or living forms. There is no known living form similar to this in New Zealand.

Phyllites laurinium Ung. Fig. 38.

This leaf scrap bears some resemblance to *Laurum princeps*, "but that does not in the slightest degree mean its complete accord."

Phyllites ficoides Ung. Fig. 39.

This was compared doubtfully with the leaves of some kinds of *Ficus*. (A smaller fragment from the Pukemiro Mine appears to be from the same kind of leaf).

Phyllites novae-zelandiae Ung. Fig. 40.

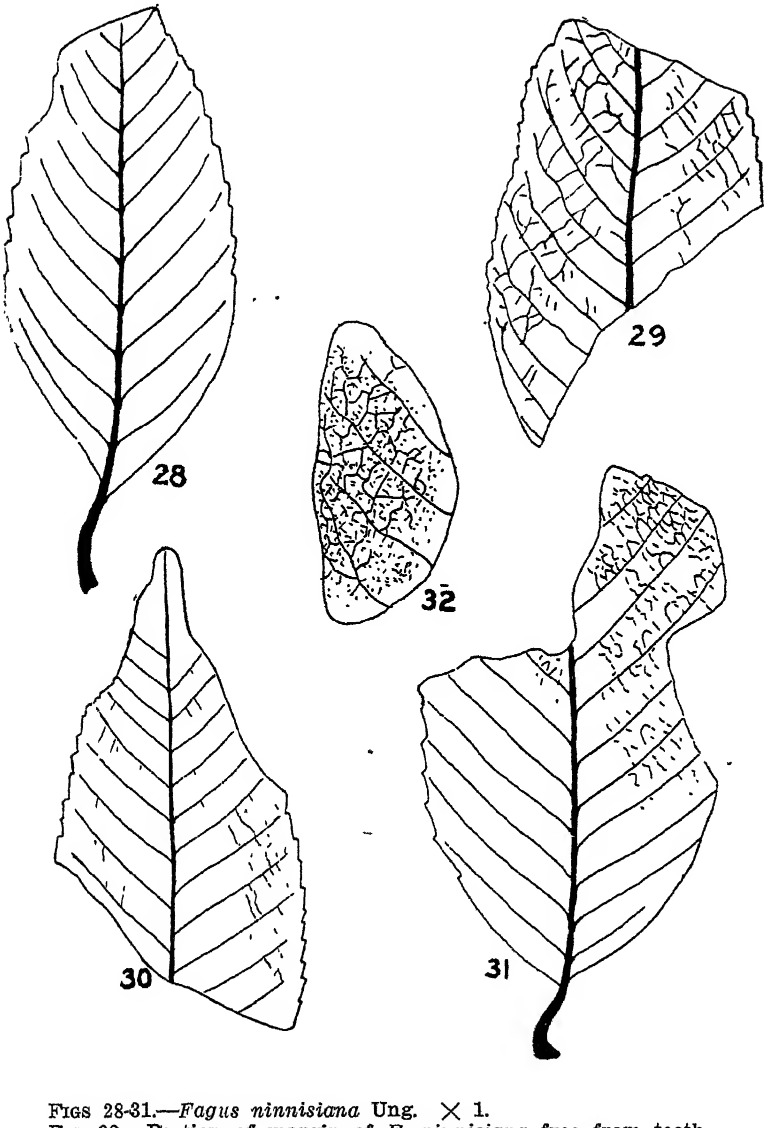
Unger found no similarity of this leaf with leaves of New Zealand trees and obtained no true identification with other living or fossil leaves.

b. *Discussion.*

These dicotyledonous leaves belong to forest trees and shrubs the modern representatives of which are confined to warm temperate or subtropical regions. They have a general Malayan character. An attempt to determine the probable plant associations from this small collection would be unwise. If more types are in the future discovered it may then be possible to reconstruct the flora which contributed the vegetable debris now constituting the coal seams of the district, although fossil leaves are but poor material for botani-

cal classification. At present the only safe conclusions are those concerning the climate and the predominantly angiospermous nature of the flora.

The latter characteristic is of great importance because it influences the nature of the peat formed from this type of vege-

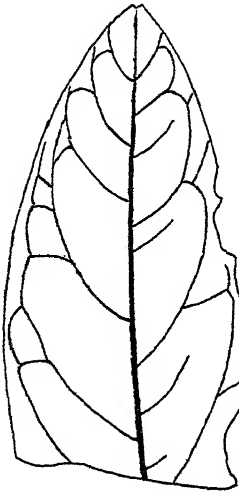


FIGS 28-31.—*Fagus ninnisiana* Ung. × 1.
FIG. 32.—Portion of margin of *F. ninnisiana* free from teeth, showing venation, × 6.

From Mr. Fallwell's place near Drury, in a coffee-brown, soft, and fine shaly claystone.

[*After Unger.*

tation, and hence that of the resulting coal. From the leaf remains collected by the writer, and also by Hochstetter and others, it can be deduced that the swamp was of the wooded or forested type in which angiosperms were the dominant form, though conifers were



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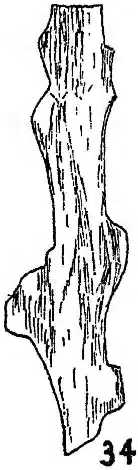

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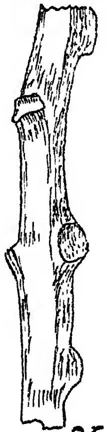

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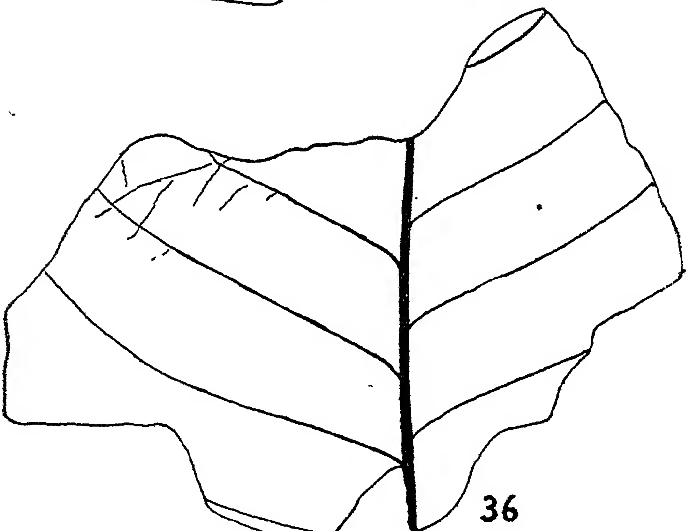

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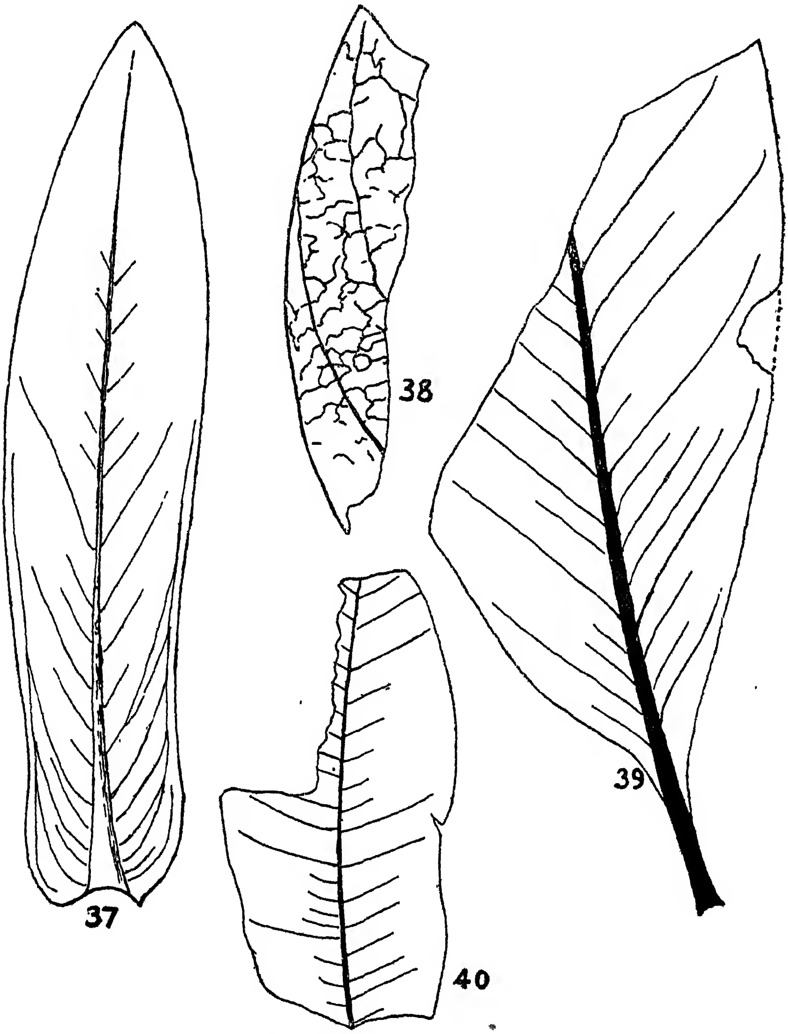
FIGS 33, 34.—*Loranthophyllum dubium* Ung. × 1.
(33.) Piece of leaf.
(34.) Piece of a twig with strongly protruding leaf cushions. From Mr. Fallwell's place near Drury, in a light grey, greasy claystone.

FIG. 35.—*Loranthus longifolius* Sprgl. × 1.
Piece of twig for comparison with Fig. 34.

FIG. 36.—*Phyllites purchasi* Ung. × 1.
From Mr. Fallwell's place near Drury, in a light grey, greasy claystone.

[*After Unger.*

present in subordinate amount as evidenced by the occurrence of resin. According to Thiessen (1928, p. 38), "Peat formed from the wooded swamp is of particular interest because it appears to be analogous to most of the bituminous coals and to many lignites



37 38 39 40

FIG. 37.—*Myrtifolium lingua* Ung. × 1.
FIG. 38.—*Phyllites laurinium* Ung. × 1.
FIG. 39.—*Phyllites ficoides* Ung. × 1.

These are from Mr. Pollock's Spring Hill Shaft near Drury, in a firm ferruginous sandstone.

FIG. 40.—*Phyllites novae zelandiae* Ung. × 1.

From Mr. Fallwell's place near Drury, in light grey, greasy claystone.

[*After Unger.*

and sub-bituminous coals. Each peat deposit that results from the different types has a distinct character. The greatest distinction is to be found in peat derived from angiosperms (the ordinary leafy trees) and that from conifers." He states further that "the angiosperms yielded readily to decay and disintegration, leaving little more than an amorphous muck or attritus; the conifers, on the other hand, wherever present, resisted decay and maceration to a far greater extent, due to their toxic resinous contents, and left a large proportion of better-preserved woody material." Coals derived from a coniferous flora are therefore always woody, whereas those derived from an angiospermous flora are always more or less amorphous. The two types are readily distinguished.

The coal from the Waikato district has the amorphous appearance described by Thiessen. It consists mainly of a relatively dull matrix in which are embedded small strips of bright coal (the "anthraxylon" of Thiessen) though in small amount only. Rarely are large strips of bright coal seen (see Penseler, 1930A).

The reason for the present characteristics of the Waikato coal is thus clear. Its origin in a freshwater wooded swamp from a predominantly angiospermous flora is evident from the palaeobotany and the geological history of the Coal Measure Series. From this type of flora, a characteristically Tertiary one, coal of a special nature is to be expected, and this expectation is confirmed by an examination of the Waikato coal.

Geological History.

During and after the planation of the Mesozoic rocks a large estuary occupied the site of the present Lower Waikato Basin. Rivers flowing into this estuary carried the products of weathering of the low lying surrounding country which, owing to the moist subtropical climate, was thickly covered with vegetation. The sediments deposited on the estuarine flats consisted therefore mainly of fine decomposed, rather than disintegrated, rock material. Organic acids leached out or reduced most of the iron compounds to a soluble state, resulting in grey or brownish grey colours. The sediments were deposited irregularly owing to the swinging of the rivers from side to side, and owing to the probable braided estuarine channels; and the gradual subsidence of the land permitted the continual building up of the sediments. Differences in the strength of the currents caused by seasonal changes in rainfall and by floods of greater or less magnitude caused differences in the nature, thickness, and colour of the sediments, and further irregularities were caused by the scouring out of previously deposited material, the by-passing of fine material, and the deposition of coarser material (see Eaton, 1929). Differential settling on an originally undulatory surface caused subsequent deposits to be not parallel, and because each successive surface of deposition would be irregular and not necessarily parallel to the preceding surface general uneveness and lenticularity of the beds was developed.

Because a subsiding land surface does not subside at an even rate, "hesitations" of longer or shorter duration occurred, and during these periods the elevation of the land remained either constant in elevation or subsided much more slowly than the average rate. At such a time then the sediments in the estuary were built up to a profile of equilibrium proper to the conditions, after which no sediment was deposited until the base level of deposition or profile of equilibrium was lowered either by the scouring out of some of the accumulated sediments during a flood, or by renewed or increased subsidence of the land. Thus there occurred periods in the history of this estuary during which the land was relatively stable, when the sediments had been built up to a profile of equilibrium, and when shallow water prevailed over a large portion of the estuary. The filling in of the dips and hollows in the old land surface by the sediments formed a broad low-lying swampy district. Conditions were then favourable for the luxuriant growth of vegetation and the accumulation of a vast quantity of vegetal matter on these swampy lands, and the extent to which it accumulated depended on the duration of the period of hesitation in subsidence. It was necessary for the inception of growth of this vegetation that the district should be above water-level for a period, but it was necessary for the accumulation of vegetal matter that a slow subsidence should be taking place fast enough to allow the peaty matter to grow and be always more or less covered with water, but not so fast that accumulation could not keep pace with subsidence. If that rate was exceeded then the vegetation was killed and the peat mass covered by muds and clays deposited to be built up to a new profile of equilibrium.

The writer does not propose here to discuss the processes and reactions taking place in the vegetal matter to form this kind of coal, and the presence of coal seams in the Coal Measure Series is considered only in the light of an event in the history of this series.

A longer or shorter period of hesitation determined the nature and thickness of the vegetal matter—a long period resulted in a seam of coal and a short period in a layer of impure coal or carbonaceous matter—but these accumulations would not be found over the whole estuary. Their occurrence, more particularly for the smaller masses, is controlled by favourable local conditions, although for a thick seam of coal it is evident that widespread favourable circumstances must have existed.

The nodules of bog iron ore were formed during some of these periods of hesitation, and may be seen forming to-day under similar conditions.

During flood times logs, branches, and general debris were washed down by the rivers. The majority of these were undoubtedly carried out to sea where they were destroyed by the scavenging animals present and by general decay. Some of the logs, however, were washed over the shallow river flats inundated by the flood and here, becoming water-logged or sticking in the muds

and clays, they were left when the flood subsided, partly or completely buried in sediment. Subsequently deposited sediment may be different in colour and texture, and in the Pukemiro Collieries some of these old fragments were seen lying at an angle to the bedding of the claystones embedded partly in one kind and partly in another kind of rock. The majority of this debris was carried some distance because the fragments are stripped bare of bark, twigs, leaves, etc. In one instance only was the "bark" still present (Fig. 8).

In periods of flood, leaves and twigs were broken up or carried out to sea. As previously noted, leaves are found in thin bedded layers which can be accounted for only by supposing that they were drifted into sheltered waters where, becoming waterlogged, they sank to the bottom and were thus deposited with the fine mud and fine carbonaceous debris to form a thin laminated layer. The state of perfection of the leaves at the time of burial depended on the distance to which they had been transported and the conditions to which they had been subjected. The roof of the coal seam in many places contains leaf remains, as would be expected because in the calm shallow waters which gradually extended over the buried vegetal matter conditions were favourable for the preservation of leaves in the fine sediments deposited from the overspreading muddy waters.

Taking into consideration the many factors and combinations of factors which could influence the deposition of sediments (including vegetal matter) in the estuary, the cause of the variations in the Coal Measure Series becomes apparent, and, conversely, these variations can be explained only by reason of their depositions in an estuary under the conditions outlined.

After the Coal Measure Series was deposited, continued subsidence of the land permitted a transgression of the sea (see Penseler 1930B), and during the first stage of the succeeding Whaingaroa Series shallow brackish water covered the site of the estuary and initiated the overlying series of marine sediments.

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On the New Zealand Lamprey, *Geotria australis*, Gray.

Part 2.—On the Mid-gut Diverticula, the Bile-duct, and the Problem of the Pancreas in the *Ammocoetes* Stage.

By F. G. Maskell, B.A., M.Sc., Ph.D.,
Lecturer in Zoology, Victoria University College, Wellington, N.Z.

[*Issued separately, 25th November, 1930.*]

Plate 74.

Contents.

1. Introduction.*

Although some observers have had at their disposal a few specimens of the *Ammocoetes* stage of *Geotria*—Kner (1869), Smitt (1901), Plate (1902), Dendy (1902)—not one, so far as I can find, has examined the internal anatomy of this interesting form. Smitt (1901) has remarked on its external similarity to the European *Ammocoetes*, from which, however, it differs in the greater number of pre-anal myomeres. What was my surprise to find, on dissection, and on examination of serial sections, that at the junction of oesophagus and mid-gut, there are constantly present two forwardly directed diverticula, a right and a left! The right is comparatively short and blind, the left is quite long, about half as long as the oesophagus, and into it upon its dorsal surface and near its anterior end opens the bile-duct. Below will be given, first, an account of the relations which the bile-duct exhibits in the Northern hemisphere *Ammocoetes*, and, secondly, will be described and figured the relations of bile-duct and diverticula as observed in the *Ammocoetes* of the Southern hemisphere lamprey, *Geotria*. It will be noted that the diverticula are lacking

*During the course of this work, I attempted to extract insulin from the insular organ (Cotronei) of *Geotria australis*, but without success. Professor J. J. R. Macleod, of Aberdeen University, kindly suggested the method of extraction, which was followed and Dr. Lynch, of the Wellington Hospital, tested the extract on mice. The mice appeared perfectly well after the injection and showed none of the expected symptoms. Only six lampreys were available for the experiment and the insular organ is very small, so the amount of material to work with was also very small. So far as I know, then, physiological evidence of the presence of insulin in this organ is still lacking.

in Northern hemisphere *Ammocoetes,* and this is the first time, to my knowledge, that they have been observed and described in the *Ammocoetes* of *Geotria.*

I take this opportunity of expressing my thanks to Mr. Kevin Rix-Trott for assistance in collecting *Ammocoetes,* to Mr. A. Waterworth for the micro-photographs, and to Professor H. B. Kirk for criticism and advice.

2. NORTHERN HEMISPHERE *AMMOCOETES.*

Brief mention of the bile-duct in these forms is made by Langerhans (1873, p. 41), Schneider (1879, p. 90), and Goette (1890, p. 75). Fig. 1 is copied from Fig. 140 of Goette, representing a dorsal view of the heart-liver region of a larval stage (neither age nor length stated) of *P. fluviatilis.* As text-books rarely describe the anatomy of the *Ammocoetes,* the following brief account of the bile-duct (Nestler) is given.

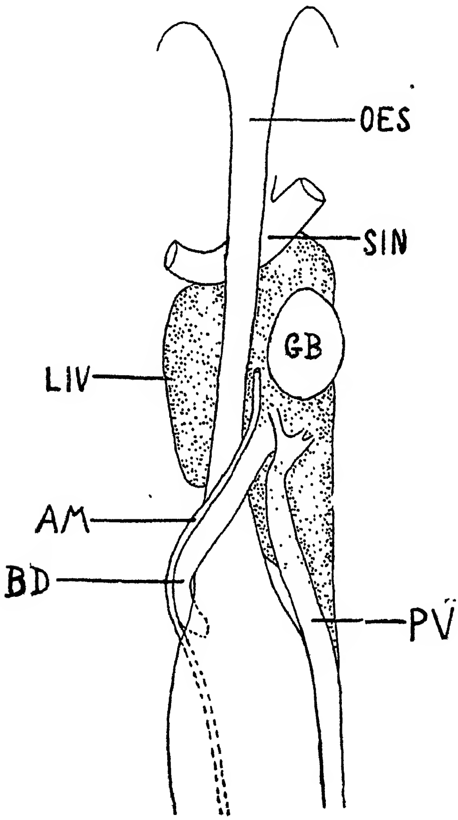


FIG. 1.—Dorsal view of gut of heart-liver region of larva of *P. fluviatilis.* (Copied from Goette, 1890). OES, oesophagus; SIN, sinus venosus; GB, gall-bladder; LIV, liver; AM, mesenteric (coeliac) artery; BD, bile-duct; PV, portal vein.

Nestler ((1890, p. 107) says "Beginnen wir die Beschreibung bei *Ammocoetes.* Eine sehr grosse und weite, von ganz niedrigem Cylinderepithel ausgekleidete Gallenblase liegt in der vorderen rechten Leberhälfte. Aus ihr kommt der Gallengang hervor. Nachdem sich die Arteria coeliaca zu ihm gesellt hat, ziehen beide, zu einem gemeinsamen Strang vereint, schräg rückwärts über den Magen hinweg auf dessen linke Seite. Hier, fast am Leberende, mündet der Gallengang in den Anfangsteil des Mitteldarmes, während die Coeliaca in die Darmfalte eintritt."

Further I have examined an *Ammocoetes* (length—10.5 cms.) of *Entosphenus appendix,* from Maple River, Cheboygan County, Michigan, U.S.A. For this specimen I am indebted to Professor Carl Hubbs of Michigan University. Here the bile-duct leaves the liver about half-way down its length, runs parallel with the coeliac artery, and both in a common strand run obliquely backwards, crossing dorsally the oesophagus and entering the mid-gut on the left dorsal side at the junction of oesophagus and mid-gut.

The above figure and descriptions will suffice to show conditions as they are found in European *Ammocoetes* (*Petromyzon*) and N. American *Ammocoetes* (*Entosphenus appendix*).

3. *AMMOCOETES* OF *GEOTRIA.*

A dissection from the dorsal surface, which requires the removal of nerve-cord, notochord, aorta, kidneys and fat bodies, exposes the diverticula and the bile-duct. The conditions exposed are essentially similar in *Ammocoetes* of 1.1 cm. length, the smallest I have yet found, and in larger specimens, till metamorphosis sets in. Metamorphosis occurs usually at a length of about 10 cms. At metamorphosis both diverticula disappear, as well as gall-bladder and bile-duct. Figs. 2 and 3 are drawn to illustrate conditions as found in *Ammocoetes* respectively of 2.8 and 9 cm. length.

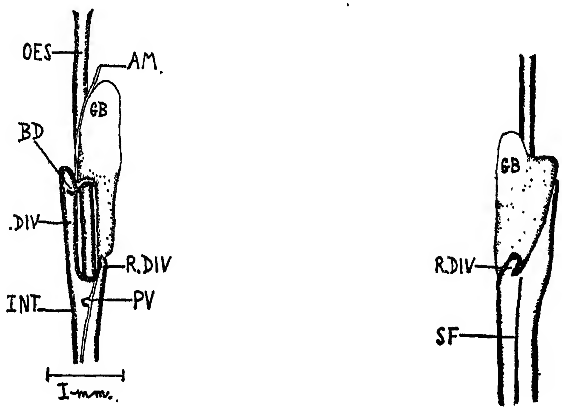
At the junction of oesophagus and mid-gut (intestine) two forwardly-projecting diverticula, a right and a left, are given off. The right is comparatively short, extends forwards only a short way below the posterior tip of the liver and ends blindly. The left diverticulum is much longer and runs forward parallel to the oesophagus. Before it ends blindly, the bile-duct opens into it on its dorsal surface. The bile-duct leaves the liver about the middle of its length, crosses the oesophagus and debouches into the dorsal surface of the left diverticulum. Though it is correct to speak of right and left diverticula, at the junction of oesophagus, diverticula and mid-gut, the oesophagus is rather more dorsally situated than the two diverticula, which lie one on either side of it and at a slightly lower level, i.e. more ventrally. (Fig. 8).

In an *Ammocoetes* of 4 cm. length, the left diverticulum measured 2.5 mm. long, the right 0.5 mm., in a specimen of 7.5 cm. length, the left 5 mm., the right 1 mm.

The liver is found immediately behind the heart region. Its ventral surface is convex, its left dorsal surface slightly concave, the oesophagus and left diverticulum resting in this concavity. (Fig. 10).

On the right side it attains its greatest development. It is broadest anteriorly, posteriorly it tapers to a point on the right side, where the portal vein enters. The anterior surface of the liver is slightly concave and fused with the posterior wall of the sinus venosus. A median ventral ligament binds the liver to the ventral body wall—this, however, is quite short and developed only in the anterior region of the liver.

The gall-bladder is located in the right anterior portion of the liver. In small *Ammocoetes,* it is relatively immense (Fig. 2), and occupies about half the volume of the liver. In such a specimen it is largely naked, i.e. not clothed by liver tissue. But as the liver grows, the gall-bladder does not keep pace with it and in a 9 cm. *Ammocoetes* it is, relatively to the liver, quite small. (Fig. 3). In



FIGS. 2a and 2b.—These represent dorsal and ventral views of dissections of the liver-region of *Ammocoetes* of *Geotria.* The scale on Fig. 2a applies to all. In all figures a = dorsal view, b = ventral view. Figs. 2a and 2b. *Ammocoetes* 2.8 cm. Lettering as in Fig. 3.

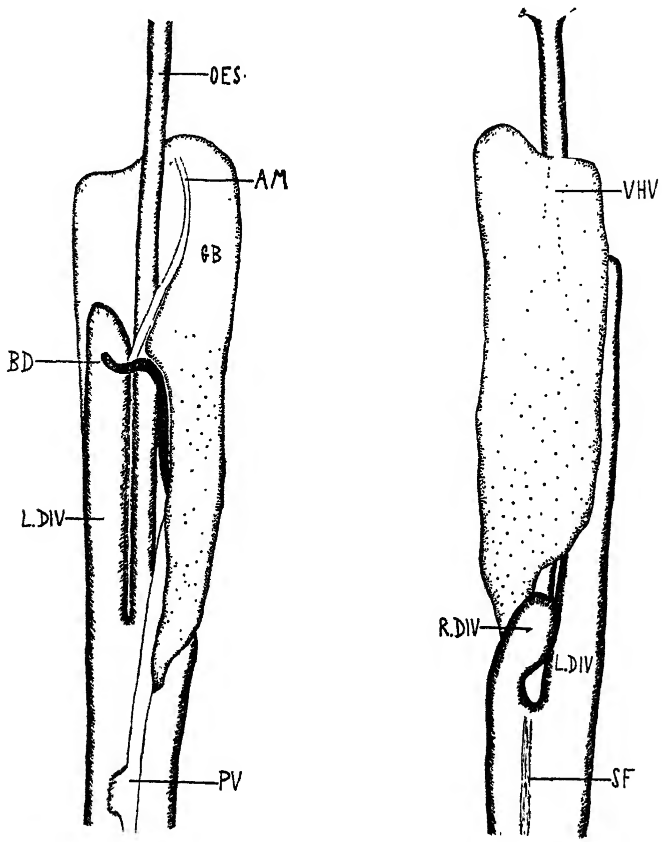
the smaller specimens (up to about 5 cms.) the epithelium lining it is very thin and flattened, in the larger specimens it is cubical to cylindrical.

The bile-duct enters the dorsal surface of the left diverticulum near the anterior end of the latter. From here we may trace it back over the oesophagus, which it crosses dorsally in the same strand of tissue as the mesenteric (coeliac) artery, to the liver. In small *Ammocoetes* it crosses the oesophagus transversely, in larger ones usually obliquely. (Figs. 2 and 3). On reaching the liver, it may be followed a short distance posteriorly before it is lost to the eye in the liver tissue.

The ventral hepatic vein with several tributaries may be observed easily on the ventral surface of the liver. (Fig. 3). It discharges into the posterior ventral region of the sinus venosus. On the right dorsal surface of the liver, close to the gall-bladder, is a much smaller

dorsal hepatic vein, which discharges into the sinus venosus. This vein runs close alongside the mesenteric artery in its short course. It is not shown in the figures.

Anteriorly, the gut-vein runs dorsal to the gut on the side opposite to the spiral fold. A short distance behind the junction of oesophagus, diverticula and mid-gut, it receives a large branch from the dorsal wall of the mid-gut. This branch is made up of veins from



FIGS. 3a and 3b.—*Ammocoetes* 9 cm. The liver is stippled, the gall-bladder clear and the bile-duct black. OES, oesophagus; AM, mesenteric artery; GB, gall-bladder; L.DIV and R.DIV, left and right diverticula; PV, portal vein; INT, mid-gut; SF, spiral fold; BD, bile-duct; VHV, ventral hepatic vein.

both diverticula, and a vein from the spiral fold. Otherwise for some distance immediately posterior to the liver it lies free from the gut. After receiving this branch, it continues forward as the hepatic portal vein to the tip of the liver which it enters. It may then be followed for a short distance along the dorsal surface of the liver, in which organ it breaks up. (Figs. 2 and 3).

The mesenteric artery (coeliac, coeliaco-mesenteric) is given off from the right side, more dorsally than ventrally, of the dorsal aorta at the level of the venous confluent. It courses to the right, obliquely outwards and backwards, through the venous confluent, which it now leaves. It then bends ventrally and runs obliquely inwards and backwards, and along the dorsal surface of the liver to which it is attached. Its course is now more or less parallel with the oesophagus. When it reaches the bile-duct, in the same strand of tissue, it crosses the oesophagus dorsally, then leaves the bile-duct which enters the dorsal surface of the left diverticulum, and now runs along the inner (i.e. right) side of the left diverticulum to the junction of diverticula and oesophagus with mid-gut. Here it enters the spiral fold as artery of the spiral fold or intraintestinal artery.

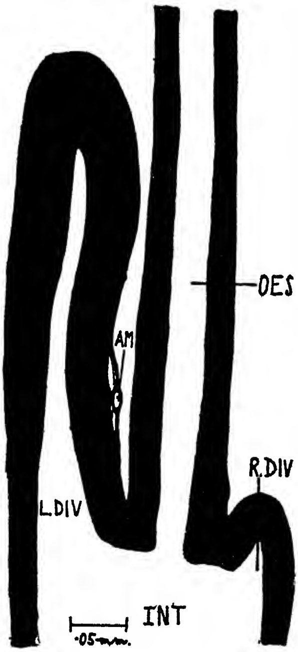


FIG. 4.—*Ammocoetes*, 1.2 cm. Horizontal (frontal) section at junction of oesophagus, diverticula and mid-gut seen from above. OES, oesophagus; L.DIV and R.DIV, left and right diverticula; INT, mid-gut; AM, mesenteric artery.

The hepatic artery is a branch of the mesenteric artery. It originates from the mesenteric after the latter in a common strand of tissue with the bile-duct has crossed the oesophagus, and either just before or just when the mesenteric becomes attached to the left diverticulum. In this common strand of tissue are present, then, bile-duct mesenteric and hepatic arteries. (Fig. 10). Thus the hepatic artery has to run back (i.e. towards the right) first, and traverse this strand over the oesophagus before reaching the liver. It is a very small artery. Arterial pads are present at its origin from the mesenteric.

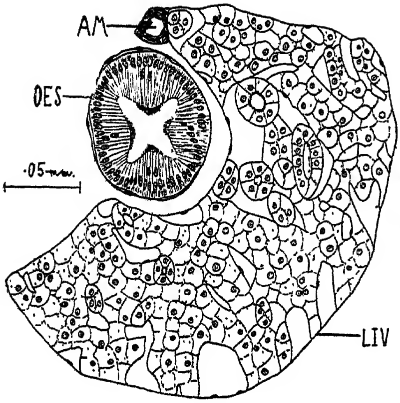


FIG. 5.

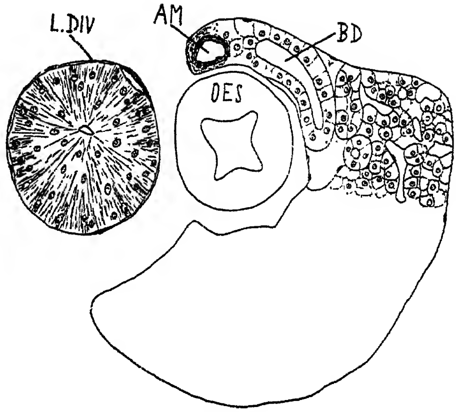


FIG. 6.

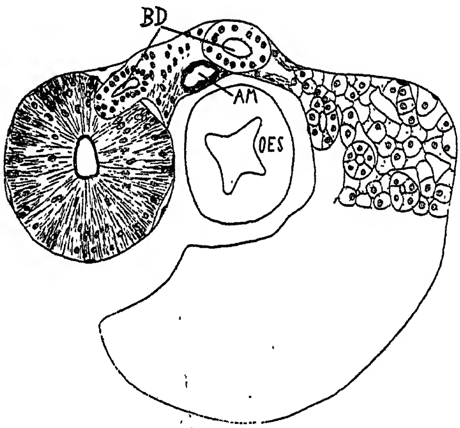


FIG. 7.

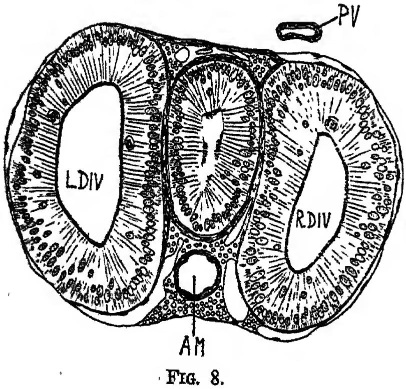


FIG. 8.

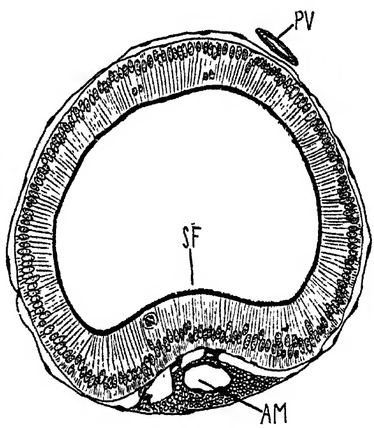


FIG. 9.

A series of cross-sections (Figs. 5, 6, 7, 8, 9) from an *Ammocoetes* 1.2 cms. long and a single section from a specimen 8.7 cms. long are given. (Fig. 10).

Fig. 4 is a horizontal section from a 1.2 cm. *Ammocoetes.*

The spiral fold originates at the junction of oesophagus, diverticula and mid-gut. Its position is then in the mid-ventral line. (Figs. 2, 3, 9).

4. HISTOLOGY.

The oesophagus is lined by a simple epithelium, the individual cells being tall and cylindrical. (Fig. 5). In cross-section the lumen is not circular, but drawn out into four bays. The cells lining the bays are somewhat shorter than the cells between two bays, and these latter cells are ciliated.

If the elements composing the epithelial wall of a diverticulum be isolated, they will be found to consist of two types of cell, which may be spoken of as columnar and glandular. (Fig. 12). Both types extend from the base of the epithelium to the lumen of the diverticulum, i.e. they are of equal length and lie side by side, so that the epithelial wall is only one cell layer deep, though exhibiting two types of cell.

The columnar epithelial cell is tall and extremely thin and attenuated—so much so that it is practically impossible to obtain a correct picture of it from sections, and it was only by isolating the two types of cell that it was possible to realise its shape. For isolation I found specimens which had been fixed in Bouin's fixative and then preserved in 10 per cent. formalin most serviceable. This type of cell is swollen at its free end, i.e. at the end lining the lumen, and these swollen ends fit in between the pointed or gently rounded ends of the glandular cells. The striated border (Stäbchensaum) which lines the lumen appears to be formed entirely at the free surfaces of the columnar cells and the glandular cells not to be concerned in it—the latter seem to end just below the striated border. The basal end of the columnar cell is also sometimes slightly swollen. The nucleus is placed about the middle of the cell—it is narrow and elongate and resembles in shape and structure the nuclei of the columnar epithelial cells lining the remainder of the mid-gut. These

FIGS. 5, 6, 7, 8 and 9.—*Ammocoetes*, 1.2 cm. long, cross sections. If Fig. 5 be regarded as Section 1, then Fig. 6 = Sect. 13, Fig. 7 = Sect. 17, Fig. 8 = Sect. 113 and Fig. 9 = Sect. 132. Sections cut at 7 microns. The scale on Fig. 5 applies also to Figs. 6, 7, 8 and 9. OES, oesophagus; AM, mesenteric artery; LIV, liver; L.DIV and R.DIV, left and right diverticula; BD, bile-duct; PV, portal vein; SF, spiral fold. Fig. 5: T.S. in region oesophagus and liver and before left diverticulum. Fig. 6: T.S. at anterior end of left diverticulum; note bile-duct and mesenteric artery passing over oesophagus. Fig. 7: T.S., bile-duct opening into left diverticulum, the actual opening is missed in this section. Fig. 8: T.S. just before junction of oesophagus, diverticula and mid-gut. Note position of mesenteric artery in what will become spiral fold. Note dividing nuclei near lumina of diverticula. Fig. 9: T.S. mid-gut with spiral fold. The caudal face of these sections is shown.

columnar epithelial cells found in the mid-gut diverticula appear to correspond with the columnar epithelial cells lining the remainder of the mid-gut, e.g. in possession of a striated border and in nuclear structure. But they have been slightly modified in the diverticula owing to the great number and relatively greater individual size of the glandular cells present which are packed between them. The modifications referred to are the attenuated shape and the position of the nucleus—in the mid-gut it is basally situated, in the diverticula it is nearer the lumen.

The glandular cells, found only in the mid-gut diverticula, I propose to describe under the following heads: *Shape*—tall, columnar, slightly wider at the base than at the end near the lumen, with gently pointed to rounded distal (i.e. near lumen) ends which appear to end within or just below the striated border, of the same height as the columnar cells described above. (Fig. 12). *Nucleus*—large, in section circular to oval, situated in the basal portion of the cell, with

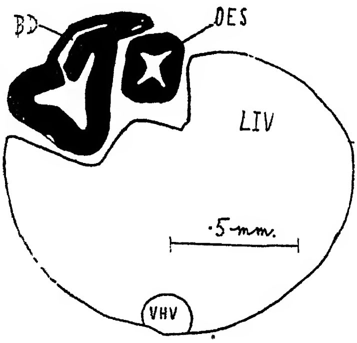


FIG. 10.—*Ammocoetes*, 8.7 cm. long, cross section. Fig. 10 shows liver, oesophagus, and bile-duct opening into left diverticulum. In same strand of tissue as bile-duct and dorsal to oesophagus are indicated mesenteric and hepatic arteries. Lettering as in Fig. 11.

prominent nucleolus, rarely two nucleoli. The nucleus has a characteristic vesicular appearance, i.e. the nuclear membrane stains, but the content of the nucleus, with the exception of the nucleolus, stains very faintly. (Fig. 11). Thus in section is seen a circular or oval margin (nuclear membrane)—the deeply stained nucleolus frequently appears attached to the inner side of the nuclear membrane—the remaining content appears clear, though high magnifications exhibit a sparse faintly-staining reticulum.

Staining Reactions: After fixation in Bouin, Zenker or Tellyesnickzy with subsequent staining in haematoxylin, the basal or proximal half of the cell stains much more deeply than the distal half. The cytoplasm in this proximal half appears as a coarse darkly staining mass, frequently exhibiting a coarsely fibrillar structure. This is particularly the case after Tellyesnickzy (acetic-bichromate) and iron-haematoxylin. The distal half of the cell after fixation as

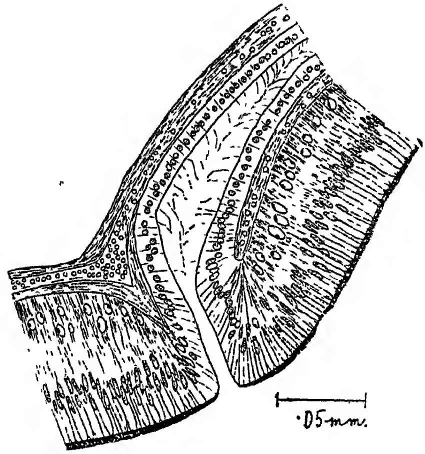


FIG. 11 shows opening of bile-duct into left diverticulum more highly magnified. (Same section as Fig. 10). OES, oesophagus; LIV, liver; BD, bile-duct. In this figure (11) the two types of cell (nucleus) in the wall of diverticulum are shown—glandular cells with basal nucleus with prominent nucleolus and columnar epithelial cells with nuclei much nearer lumen. Note flagella in bile-duct. Fixation—Bouin.

above and staining with haematoxylin is much clearer and lighter than the distal half—it contains faint but distinct indications of granules—the granules appear as if partially dissolved out. With iron-haematoxylin the granules are rendered more distinct—it is then seen that they are closely packed at the free end of the cell, ready, no doubt, to be cast into the lumen. From this closely packed area

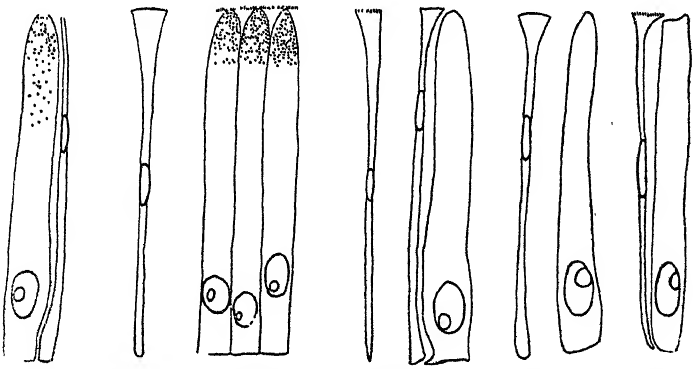


FIG. 12.—Cells of the left mid-gut diverticulum after isolation. The two types are shown.

the granules may be traced in diminishing number to about one-third way down the length of the cell. Benda's fixation test for secretion granules (Bolles-Lee, 1921, p. 315) followed by Mallory's triple stain —makes evident the granules in the closely packed area near the

lumen—they are stained red. Strangely enough, the other end of the cell—the region below the nucleus—shows the same staining reaction as the granules—it is also red. The significance of this will appear when the mitochondria are discussed.

Mitochondria: The fixatives of Regaud, Champy and Gatenby followed by iron-haematoxylin were used to demonstrate mitochondria. The method of Gatenby (Flemming-without-acetic and iron-haematoxylin or briefly, F.w.a.) was most useful. By these methods the cytoplasm is stained a homogeneous gray, while granules and mitochondria stain in the same way, i.e. both appear blue-black on the gray background. The mitochondria are abundant at the basal end of the cell, i.e. between the nucleus and the base of the cell, the granules are abundant at the free end of the cell, so that these two opposite regions of the cell are more deeply stained than the intervening region. At the basal end the mitochondria form a tangle—they frequently give the appearance of a cap or a wig of closely interwoven threads seated on the proximal (basal) end of the nucleus. They are very thin structures and appear sometimes as threads, at other times rather as linear aggregations of dots. From this tangle isolated threads emerge, passing up around the nucleus towards the middle region of the cell. These isolated threads may be observed only in very thin sections and may be traced distally to about one-third the length of the cell. Here they come into relation with a structure which I shall refer to as the *clear area or vacuole*. This at first puzzling structure was first noticed in F.w.a. preparations. Above the nucleus there is frequently to be seen a large and distinct vacuole, as large as the nucleus or larger. (Fig. 13, b, c, d). Within this vacuole any one of the following appearances may be seen (1) a faint reticulum with granules on it, (2) a collection of granules, (3) a number of fairly large globules, deeply stained, (4) two, three or four deeply stained masses, or finally (5) the vacuole may contain a single immense deeply stained mass.

The mitochondria which emerge from the tangle and extend up alongside the nucleus can be seen in favourable cases to reach the vacuole, and at or in the vacuole they appear to give rise to the granules. The large deeply-stained globules or the deeply-stained masses, which are seen at times in the vacuoles, I am inclined to attribute to the fusion of granules—such fusion perhaps being a result of fixation or depending on the particular state of the granules at that time. In all cases fixation was as rapid as possible—the head was cut off, the organs rapidly dissected out and placed in the fixative.

A re-examination of material preserved in Bouin showed that the vacuole was present here also—in any one section a number of cells exhibited the vacuole. The vacuole sometimes appeared empty—usually it contained a mass of stained material, which did not fully fill the vacuole. A more deeply-stained dot was usually noticeable in the middle of the stained mass. (Fig. 13, e). Vacuoles were also abundant in material fixed by Lane's method mentioned below, they were rare in acetic-bichromate material. More careful examination of F.w.a. material now revealed the fact that in cells, which did not

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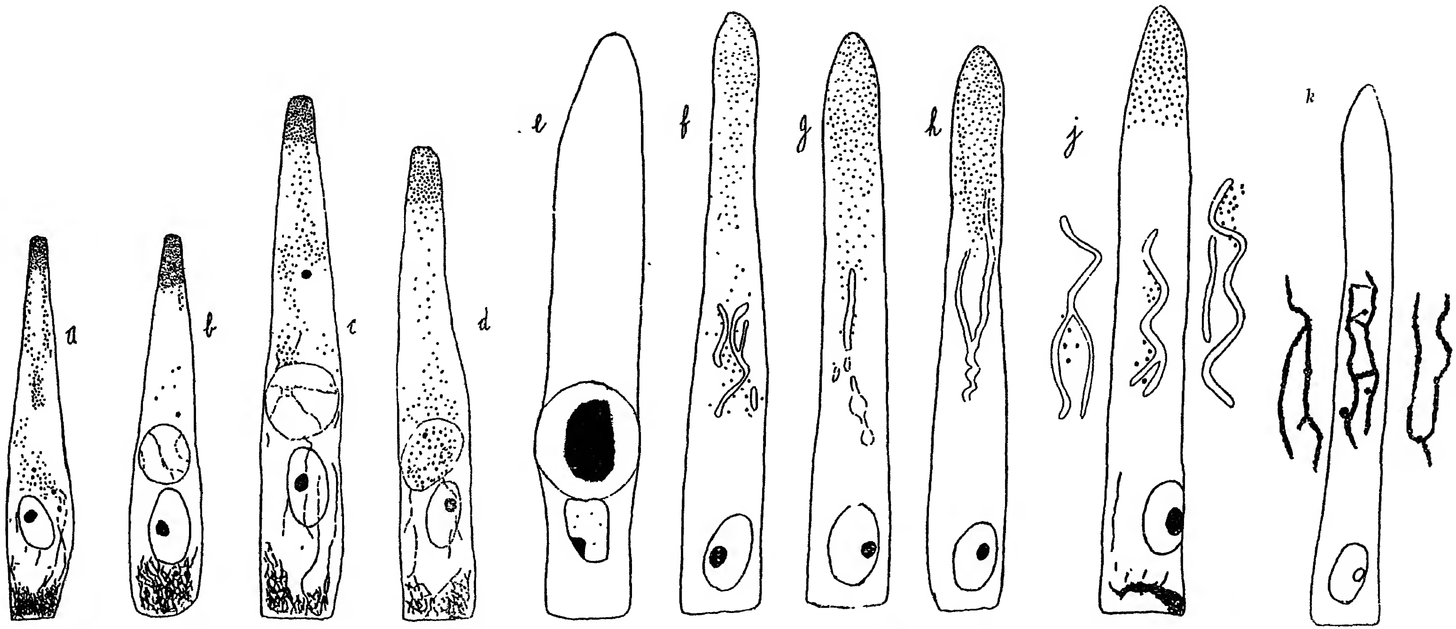

FIG. 13.—Glandular cells of the left mid-gut diverticulum. a, b, c, and d = from Flemming-without-acetic and iron-haematoxylin preparations. Note basal tangle of mitochondria, nucleus with nucleolus, clear area (vacuole) with mitochondria reaching to it and granules. In *a* the clear area above nucleus was vague and ill-defined. e = from Bouin to show vacuole; f, g, h = from F.w.a. and iron-haematoxylin showing indications of canalicular system; j = from Regaud (formol bichromate) showing canalicular systems with prozymogen granules of three cells—mitochondria and nucleus shown in middle cell; k = from Mann-Kopsch preparations. Golgi network of three cells.

exhibit a vacuole, there was nearly always present in the corresponding region a clear area—this might be just a vague clear area, two or three small circular areas, vague indications of clear canals (canaliculi) or a definite system of canaliculi. Thus in F.w.a. material structures varying from a canalicular system to a vacuole may be seen—all occupying similar positions above the nucleus and about the middle of the cell. (Fig. 13b, c, d, f, g, h). In material prepared by Regaud's formalin-bichromate method, vacuoles are practically absent. I could find only two or three—on the contrary, the intracellular canalicular system is excellently shown (Fig. 13j). It takes the form of a system of clear canaliculi—three examples are shown. An attempt was next made to impregnate the Golgi apparatus—by Cajal's method (Da Fana cobalt nitrate modification) no success was obtained, though several trials were made. By the Mann-Kopsch method, however, an apparatus was blackened about the middle of the cell, occupying a position very similar to that occupied by the canalicular system. Three examples are shown (Fig. 13k). Many observers are of the opinion that Golgi network and canalicular system represent different pictures of the same apparatus, i.e. in formalin-bichromate the material is dissolved out leaving clear canals, in osmic acid impregnations the material is heavily blackened, leaving black cords. If this be so, the most accurate picture of the structure in question is given as Golgi network (Mann-Kopsch) or canalicular system (Regaud's formol-bichromate) and the various structures seen in F.w.a. preparations, varying from canalicular system to vacuole, together with the vacuole itself, represent apparently distortions of the canalicular system. One further point of interest is this—granules are always found associated with this vacuole, clear area or canalicular system, both in F.w.a. and in Formol-bichromate preparations—this is the most proximal region of the cell in which granules are to be seen—from here they may be followed distally to the free end of the cell. That the first-formed granules (prozymogen of Saguchi) are formed under the influence of the canalicular system (Golgi apparatus) there seems no reason to doubt, and from what has been said before, there is reason to believe that the material of which they are formed is derived from the mitochondria.

The thesis I wish to maintain is this—that the glandular cells, which characterise the diverticula, are to be regarded as pancreatic cells comparable to the exocrinous pancreatic cells of vertebrates: in other words, there is in the *Ammocoetes* stage of *Geotria* no definite and compact pancreatic gland, but the pancreatic (exocrinous) cells are still scattered in the gut wall in the diverticula. The endocrinous constituent of the pancreas (Islets of Langerhans in vertebrates) is represented by the Follicles of Langerhans in the *Ammocoetes*.

Schafer (1916) in discussing the pancreas remarks:

1. That the inner two-thirds of the cells are filled with granules;

2. That in haematoxylin-stained sections the outer part of the cell is coloured more deeply than the inner;

3. That pancreas cells frequently exhibit a rounded mass of mitochondria near the nucleus.

Horning (1925) has shown that in the guinea-pig the zymogen granules are constricted off from the ends of the mitochondria. Saguchi (1918) has made an intensive study of the glandular cells of the frog's pancreas. He finds—

1. The nucleus is provided with usually only one nucleolus.

2. After fixatives containing a large amount of acetic acid the basal portion of the pancreatic cell exhibits a fibrillar structure and stains more deeply with haematoxylin. I find the same in the *Ammocoetes,* particularly after fixation in acetic-bichromate. (Telly-esnickzy). According to Saguchi, this is due to the presence of his "protofibrillae," which he regards as morphological constituents of the cell. In fixation some of the plasm is removed, the protofibrillae thus individualised and a certain amount of adhesion of them follows, hence the fibrillar structure seen in sections. The protofibrillae are not to be confused with mitochondria.

3. The mitochondria have the form of rods or filaments and are crowded round the nucleus. The mitochondria are used up in the formation of the zymogen granules. Saguchi derives the mitochondria from the nucleus.

4. Zymogen granules are never found between nucleus and basement membrane. Above the nucleus is a clear area—"secretogenous area"—to this the mitochondria converge and here small granules (prozymogen) are formed by the disintegration of the mitochondria. The granules leave this area, increase in size and collect at the free end of the cell as zymogen granules.

5. The Golgi apparatus is placed above the nucleus. It appears to occupy the same position as the "secretogenous area," where the granules are formed from the mitochondria.

6. After Regaud's fluid (and others) a system of canaliculi with clear lumina may be observed in the "secretogenous area"—within the meshes of this system are prozymogen granules—Saguchi considers the canalicular system is to be identified with the Golgi apparatus, the former being the negative of the latter.

From my own observations I can affirm that the nucleus of the pancreatic cells of trout, frog (*Hyla aurea*) and rat appears clear and vesicular with a prominent nucleolus. Lane's method for pancreatic islet tissue (Carleton, 1926, p. 279) stains also the zymogen granules of the acinous cells. Pieces of frog pancreas and the *Ammocoetes* diverticula were prepared by this method. The zymogen granules (frog) and the granules of the glandular cells (*Ammocoetes*) reacted to the stain in just the same way—both were stained purple.

From the comparisons made above I venture to say that the glandular cells found in the diverticula (*Ammocoetes*) may be compared to the exocrinous pancreatic cells of the vertebrates. If this be a true comparison, an interesting conclusion follows. We then have in the *Ammocoetes* the most primitive condition of the pancreas, i.e. the pancreatic cells are still scattered in the gut wall and not compacted into a definite gland. So far as I can find, no pancreatic cells have been described in *Amphioxus.* Further, such cells (glandular, pancreatic) almost certainly occur in European *Ammocoetes,* as I shall attempt to show below.

One further point should be noted here—as mentioned before, the epithelium lining the diverticula is provided with a striated border. Within this border may be seen tiny dots or rods (Fig. 11), and in tangential sections it can be seen that these are really sections of a network placed in the striated border. Krause (1923) figures a similar structure in the " Stäbchensaum " of the gut-epithelium of the pike. This structure is the " Schlussleistennetz " or network of terminal bars.

5. Discussion.

After studying these glandular cells in the mid-gut diverticula of New Zealand *Ammocoetes,* the question naturally arose—do such cells occur in European *Ammocoetes?* The mid-gut diverticula are absent in such forms—the anterior portion of the mid-gut suggests itself then as the most probable spot. I have not been able to observe European *Ammocoetes* myself—but the reports of two earlier investigators—Brachet (1897, 1897a), and Picqué (1913)—have convinced me that such cells occur.

Brachet (1897), at the end of his paper, draws attention to a point in European *Ammocoetes* which he considers of importance. It is this: "La texture de l'épithélium de l'intestin moyen, est toute différente, dans la partie antérieure, qui fait immédiatement suite au 'Vorderdarm,' de ce qu'elle est dans le reste de son étendue." Here among the ordinary epithelial cells, "on trouve un très grand nombre de cellules toutes spéciales," which stand out strongly when stained (borax-carmine, safranin) from the others. " Ces cellules, très allongées, s'étendent de la membrane propre à la surface libre de l'épithélium: leur extrémité tournée de ce dernier côté est garnie d'un plateau strié, moins élevé, semble-t-il que celui des cellules ordinaires de l'intestin moyen. Le corps de ces cellules, fortement coloré en rouge, par le carmin ou la safranine, se montre constitué de deux moitiés assez nettement distinctes. La moitié externe est homogène ou très finement granuleuse. C'est elle qui contient le noyau. La moitié interne dirigée vers la surface libre de l'épithélium, se colore moins fortement par le carmin, est moins homogène, montre des granulations plus ou moins nombreuses, et des taches claires irrégulières " . . . . . " Ce qui caractérise encore ces cellules, c'est l'aspect tout particulier de leur noyau. Il est constitué d'une mince membrane, très peu chromatique, et d'un réticulum très fin, également très peu chromatique. Au centre du noyau se voit un très gros nucléole, absorbant très fortement les matières colorantes. Il semble que toute la chromatine du noyau s'est condensée dans ce corpuscule." Brachet remarks first on the zone which these cells occupy " dans la portion initiale de l'intestin moyen," secondly on their characteristics which suggest those of pancreatic cells. He remarks on Mayr's conception—that in the ancestors of the Selachians, having as yet no pancreas, there must have existed a zone, occupying the dorsal region of the mid-gut, and containing the materials at the expense of which the pancreas forms itself among actual Selachians. " Chez l'*Ammocoetes,* cette zône paraît exister,

mais elle n'occupe pas seulement la partie dorsale de l'intestin moyen; on la retrouve sur toute sa circonférence. Si c'est là réelement une zône pancréatique, ce que je crois, on peut admettre qu'elle contient les matériaux aux dépens desquels s'édifieront non seulement le pancréas dorsal, mais aussi le pancréas ventral.''

The agreement between these cells described by Brachet and those described by me in *Geotria Ammocoetes* is striking—position of nucleus, nuclear structure, nucleolus, division of cell body into two halves, presence of granules in inner half. It will further be obvious that the thesis maintained here is not original—it was suggested first by Brachet so far back as 1897, but no one since appears to have followed it up. It was Brachet's paper which suggested to me an explanation of these glandular cells and gave me a means of linking them up with similar cells in European *Ammocoetes.*

Picqué's paper (1913) is longer, and I do not agree with his main conclusions, but certain points brought out are of interest as regards the glandular cells. He considers a pancreas is present in *Ammocoetes* and in adult—in his view, with which I disagree—it is formed in the *Ammocoetes* by the follicles of Langerhans, in the adult by the organ constituted by an aggregation of such follicles, which Cotronei (1927) has since identified as an insular organ. Picqué studied the origin of this organ in very young *Ammocoetes* (5 mm. to 7 mm. long in *P. planeri*) and I copy his scheme as Fig. 14. Where the oesophagus is continuous with the mid-gut, two pads, a dorsal and a

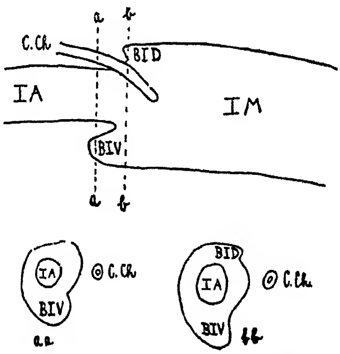

FIG. 14.—Scheme showing the disposition of the "bourrelets (pads) d'invagination de l'intestin antérieur (IA) dans l'intestin moyen (IM)." Copied from Picqué (1913). This scheme refers to young larval forms of *P. planeri* and *P. fluviatilis.* C.ch. = bile-duct; BID and BIV, dorsal and ventral pads.

ventral, are formed by the oesophagus being slightly invaginated into the mid-gut. The ventral pad is the larger. It is at the level of these pads that the follicles of Langerhans (pancreatic rudiments of Picqué) are formed. Picqué's sections through these pads show externally follicles of Langerhans and internally the intestinal epithelium. The interesting point is this—that in this epithelium two kinds of nuclei are present—nuclei such as occur in the remainder of the intestine and nuclei with large nucleoli, standing out sharply from

the others. On p. 21 we read: "Puis le bourrelet (pad) se dessine (Pl. 1, Fig. 1), constitué par une masse d'éléments cellulaires, dont les noyaux sont surtout caractérisés par un nucléole en général unique et assez volumineux. Ces cellules à gros karyosomes font manifestement partie de l'épithélium intestinal." Farther down on the same page, "Les coupes suivantes nous conduisent en plein bourrelet. Ici les noyaux innombrables tranchent absolument sur ceux de l'épithélium intestinal par leur nucléole unique, gros et de volume croissant vers le dehors." Picqué does not explain the presence of these nuclei with large nucleoli. He recognises clearly, however (p. 41), the presence of two types of cells in the epithelium of the pads and thinks the follicle cells (his pancreatic cells) may come from the cells with big nucleoli, but is not sure. He does not discuss these nuclei with big nucleoli any further.

I believe they are the nuclei of the cells which Brachet (1897) had already described in older *Ammocoetes*. Again Picqué's sections showing the mid-gut epithelium (pads) with two kinds of nuclei show a striking agreement with my sections of the diverticula.

To summarise—in these three cases—the pads of Picqué in *Ammocoetes* of 5 to 7 mm. length—the epithelium of the most anterior portion of the mid-gut in European *Ammocoetes* (Brachet 1897)—the mid-gut diverticula of *Geotria Ammocoetes*—we find a feature common to all—characteristic cells denoted in particular by a nucleus with a large prominent nucleolus. As I have indicated above, these cells are to be compared to the pancreatic (exocrinous) cells of Vertebrates.

It seems possible that Picqué's "pads" and the diverticula of *Geotria Ammocoetes* are to be regarded as homologous structures, but that in the former case they develop very slightly while in the latter they increase enormously. However, the pads are dorsal and ventral (Fig. 14), while the diverticula are right and left. I have not been able to obtain *Ammocoetes* smaller than 1.1 cm. long, so as to whether there is any change of position as regards the diverticula in earlier stages I cannot say. That a rotation of the gut may occur is not improbable. A rotation of the gut (*Geotria*) certainly occurs at metamorphosis, as I have been able to observe.

The position of the follicles of Langerhans is another point of agreement. Picqué finds them in the furrow or groove between oesophagus and the pads of the mid-gut—in *Geotria* they occupy a similar position, i.e. in the furrow between oesophagus and the origin of the mid-gut diverticula.

Keibel (1927) in his Fig. 8 gives a frontal section passing through the passage of fore-gut into mid-gut of an *Ammocoetes*, 7.5 mm. long, of *Lampetra fluviatilis*. The section shows two structures (Wülste) which strongly suggest pads (bourrelets) or the rudiments of mid-gut diverticula. From the section they are right and left, and the left is the larger. Their histological structure cannot be observed. It would be interesting to know if the two types of nuclei (cells) described above are present in them. In his Fig. 10 Keibel shows a sagittal section at the passage of fore-gut into mid-gut of an *Ammocoetes* 9.2 mm. long, of *Lampetra planeri*. In the legend he remarks

"Keine Wülste zwischen Vorderdarm und Mitteldarm, aber Epithelgrenze."

Considering these two sections, therefore, we see that the "Wülste" (structures which I have referred to as suggesting "bourrelets" or rudiments of mid-gut diverticula) are right and left, and absent dorsally and ventrally. They therefore certainly suggest structures, only slightly developed and homologous with the mid-gut diverticula of *Geotria* larval forms.

Finally it would have to be supposed that in *Geotria* one pad or diverticulum (the left) had carried forward with it in its development the opening of the bile-duct, since this no longer opens at the junction of oesophagus and mid-gut, but far forward into the left diverticulum.

6. CONCLUSION.

In this paper the following view is taken regarding the question of the pancreas in lampreys:

a. Both constituents of the pancreas (exocrinous and endocrinous) occur in the *Ammocoetes* stage. The exocrinous constituent is represented by the glandular cells occurring in the anterior region of the mid-gut—in *Geotria* in the mid-gut diverticula. The endocrinous constituent is represented by the follicles of Langerhans.

b. Only the endocrinous constituent persists in the adult. At metamorphosis the follicles of Langerhans increase in number and become aggregated together to form a definite gland. This is the insular organ which Cotronei (1927) has already described as being composed of insular tissue. In *Geotria* the diverticula are lost at metamorphosis and with them the glandular cells (exocrinous constituent). Probably these cells are lost also in European *Ammocoetes* at metamorphosis, but this would have to be ascertained.

7. SUMMARY.

1. The *Ammocoetes* stage of *Geotria australis* possesses two forwardly-directed mid-gut diverticula, a left and a right. Into the left opens the bile-duct. Such diverticula are unknown from other *Ammocoetes.*
2. The diverticula contain characteristic glandular cells which are to be compared to the exocrinous pancreatic cells of Vertebrates.
3. In the *Ammocoetes* stage the pancreas is not yet differentiated as a special gland—we have a stage in which the pancreas cells are found distributed in the epithelium in a certain section of the gut wall. This view was first expressed by Brachet (1897a, p. 773). This paper attempts to confirm this view and to bring fresh evidence in support of it from the study of *Geotria.*

Addendum: Through the kindness of Dr. Horst Boenig I have received a copy of his recent paper—Studien zur Morphologie und Entwicklungsgeschichte des Pankreas beim Bachneunauge (*Lampetra* (*Petromyzon*) *planeri*). III Teil. Die Histologie und die Histogenese. *Zeitsch. für mikr-anatom. Forschung*—17 Band, 1/2 Heft, 1929. Unfortunately I have not got part 1, nor is it obtainable in New Zealand, consequently in the criticism which I offer I feel rather handicapped by not knowing its contents. Dr. Boenig considers that the Follicles of Langerhans, formed as buds from the gut wall and from the epithelium of the bile-duct, constitute in the lamprey a pancreas " Morphologisch dem Pankreas der Höheren Wirbeltiere homolog " (p. 181). Essentially the same view has been expressed before by Picqué (1913) and by Keibel (1927). For the following reasons I cannot subscribe to this view: 1. In Vertebrates the liver and the pancreas originate at practically the same time—here, however, the first indications of the "pancreas"? appear after the liver is completely formed—according to Boenig in 1.2 cm. *Ammocoetes*—further during the whole larval life "pancreatic" buds continue to be formed, while at metamorphosis the epithelium of the bile-duct proliferates strongly, forming many more "pancreatic" buds (caudal pancreas of Boenig), the bile-duct, as such, disappearing. 2. Though, in the adult lamprey, the cranial and caudal sections of the "pancreas" are respectively dorsal and ventral in position and hence are compared by Keibel and Boenig to the dorsal and ventral pancreas of higher Vertebrates, Boenig (Part 2, p. 591, 1927) himself admits, "dass der Entstehungsmodus des ' dorsalen und ventralen Pankreas ' bei *Lampetra planeri* ein ganz anderer ist als der bei den anderen Wirbeltieren" and again "Beim *Ammocoetes* findet sich weder eine 'dorsale' noch zwei 'ventrale' Pankreasanlagen." In fact, the formation of the lamprey "pancreas" will not fit in with any scheme of pancreas-formation, which holds good for other Vertebrates. 3. There is no pancreatic duct—at no time is there ever any indication of one. 4. There is no zymogen tissue nor ever any sign of such.

Since the main characteristics of the pancreas, as we know them from other Vertebrates, appear to be missing here, the homology with the Vertebrate pancreas drawn by Picqué, Keibel and Boenig seems to me of very doubtful value. There remains, however, the view originated by Brachet (1897) and advocated in this paper. So far as I know, there is nothing incompatible in the view that these follicles or buds represent islet tissue, either as regards their origin or structure. Cotronei (1927) has already described the "pancreas" of Boenig as an insular organ. The remarkable cells present (a) in the anterior region of the mid-gut in European *Ammocoetes* (b) in the mid-gut diverticula in *Geotria Ammocoetes,* bear so many and striking resemblances to pancreatic (exocrinous) cells that it seems reasonable to regard them as such. Neither Picqué, Keibel or Boenig are able to offer any explanation of these cells.

Two further points in Boenig's paper call for notice. Dr. Boenig constantly speaks in Part 3 of the follicles (his pancreas) as being derived " durch Wucherung des Vorderdarmepithels " (p. 179), also on pages 137, 145, 146, 164, etc. This appears strange, since both

Fig. 15.—Microphotograph: T.S. wall of left diverticulum. F.w.a. and iron-haematoxylin. Note basal tangle mitochondria, nucleus with nucleolus (black), clear areas (circular) and granules in inner half of cell.

[*Photo. by A. Waterworth, Esq.*

Fig. 16.—Microphotograph: T.S. wall of left diverticulum. Regaud preparation to show canalicular system. This system is found about the centre of the cell and shows clearly in the cell marked with a cross.

[*Photo. by A. Waterworth, Esq.*

Picqué (1913) and Keibel (1927) speak of the follicles as being derived from the mid-gut epithelium, while Boenig himself in Part 2 derives the follicles from the mid-gut epithelium e.g. "Das Pankreas legt sich zunächst; aus dem Epithel des Mitteldarmes enstehend, multipel in Form einer Spange ...." (p. 590). Again on p. 144 Dr. Boenig speaks of Brachet's pancreatic cells as being in the fore-gut epithelium, but according to Brachet (1897) and Picqué (1913) these cells are located in the mid-gut epithelium. In *Ammocoetes* of *Geotria* they are in the mid-gut diverticula.

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Raised Beaches and other features of the South-east Coast of the North Island of New Zealand.

By L. C. King, B.Sc., Victoria University College.

[*Read before the Wellington Philosophical Society, 13th August, 1930; received by Editor, 17th August, 1930; issued separately, 25th November, 1930*].

Plates 75–80.

Contents.

Introduction.

The district described in this paper comprises the coastline of the southern and south-eastern portion of the North Island of New Zealand. A narrow strip of country inland from the coast itself was also examined, so that the bearing of the rocks of each locality on the type of coastline could be considered. Thus the description of each strip of coast is prefaced by a note on the geological structure, or the rocks of the locality, as it has been found that the type of present-day coastline is profoundly affected by the geological formation of the country.

Literature on the coastal features is fairly complete for the Wellington area, Crawford, Park, Bell, Cotton, Adkin, and Aston having each contributed one or more papers; but the Wairarapa coast has received little attention. Crawford and A. McKay recorded raised terraces but neither described them, though McKay estimated the height of the Palliser Bay platforms. Hence this portion of the work provided a virgin field.

The thanks of the writer are here gratefully extended to all those who have so kindly afforded him accommodation on a much exposed and thinly populated coast, without which help the work would have been extremely arduous. To Mr. Jobberns, of Christchurch, his sincere gratitude for a trip along the Canterbury raised terraces is here expressed. The writer is also indebted to Dr. Cotton for permission to reproduce one of his sketches. (Fig. 4).

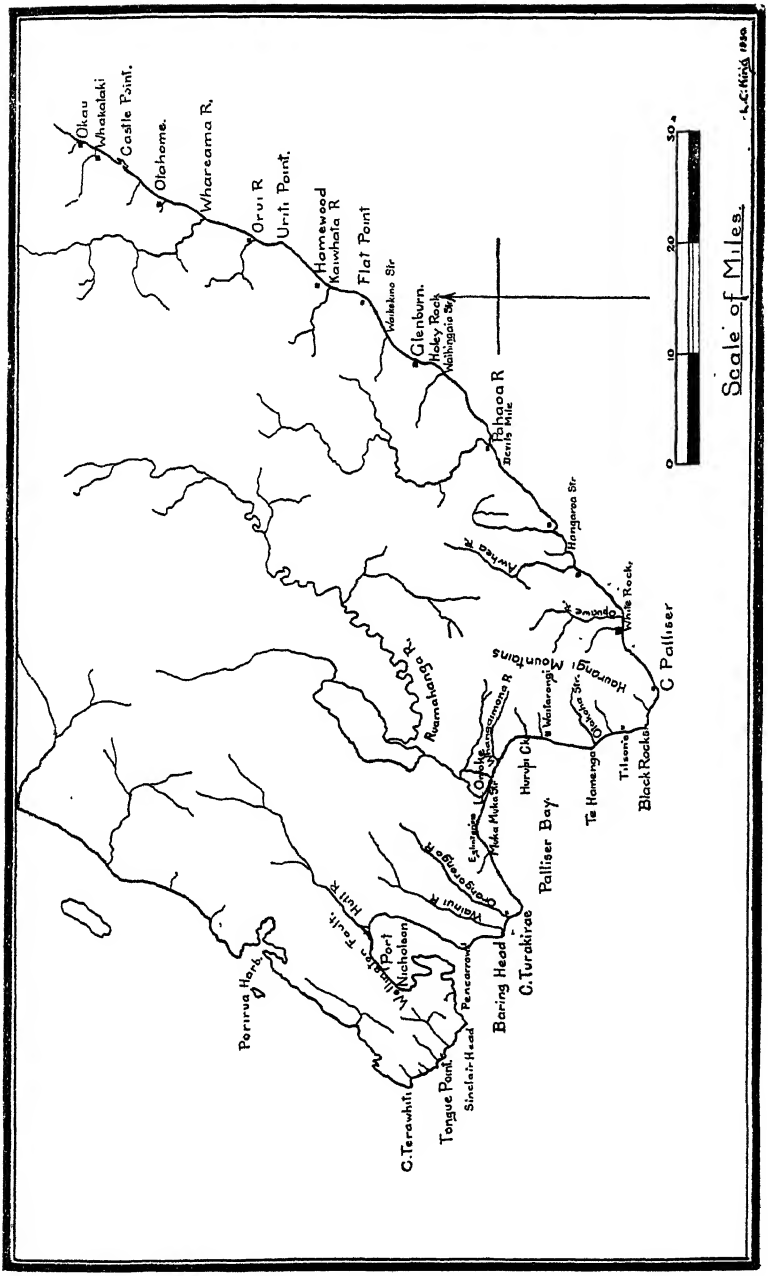

FIG. 1.—Map of Southern Portion of the North Island of New Zealand.

Cape Terawhiti to Port Nicholson. (18 miles).

Geographically, Cape Terawhiti provides a very convenient starting point for this paper, for it is the most westerly point of the south coast of the North Island and so forms the western limit of one of the coasts with which this paper is concerned. Furthermore, it is shown on the majority of maps and so is widely known, in name at least. From Terawhiti east, as far almost as Lake Onoke at the head of Palliser Bay, the rocks consist of a single series of hard, contorted greywackes and argillites across the strike of which, the shoreline cuts, for the main part, at right angles. The coast is bold and rugged, the country rising rapidly to over 1000 ft. Usually, cliffs several hundred feet high front the sea, which, until recent times, has been strongly attacking them. Owing to a comparatively recent movement of the strand the sea no longer reaches quite to the foot of the cliffs. The present shoreline consists of stretches of sand or gravel beach, alternating with wave-cut platforms which project seaward from many of the more prominent headlands.

So far as any discussion on the raised beaches of the district is concerned, Terawhiti is again most suitable, for, just south of the Cape itself is a splendid example of a marine cut platform which has been raised to a height of 125 ft. above sea-level. The surface is smooth; only a few stacks 6 ft. high, now rapidly disappearing under the action of the normal subaerial agencies, still stand above the otherwise level surface. The rear edge of the platform is covered in part by talus, accumulating at a rapid rate from the steep slopes, which rise sharply to a height of 1500 ft. This makes somewhat difficult any accurate determination of the amount of uplift that has taken place, but the mean of a number of estimates gives a value of 125 ft. A covering of six or eight feet of discoidal gravel, up to $\frac{3}{4}$ in. in diameter, may be seen where the protecting grass has been removed. This thinness of the gravel cover is characteristic of all the platforms from Terawhiti to Tongue Point. The explanation may be that, just as the strong swell and current causing the Terawhiti tide rip pass through Cook Strait to-day, so, during the period in which the benches were cut, there was a strong tidal or ocean current which swept most of the debris, derived from the land and resting on the cut shelf, off into deep water, thus keeping the rock surface compartively clean.

A remnant of a higher platform, now 250 ft. above sea level also occurs at Cape Terawhiti. The surface of this platform is almost completely obscured by talus but there can be no doubt of its existence, especially when seen in profile from the other side of Oterongu Bay. (Plate 75, Fig. 1). This prominent higher bench is of the utmost importance as it occurs in every locality along the south coast where the lower or younger platform is well developed; but, just as the lower is present at different heights in different localities, so there is no constant height, or ratio of heights, between the upper and lower platforms. This seems to prove that warping and tilting occurred either during or between the periods of uplift, just as differential warping of a comparatively late age has been

shown by Cotton (1921B, p. 131 *et seq.*) to have governed the form of the Port Nicholson depression.

Along almost the whole of the coast from Terawhiti to Tongue Point the lower platform is continuous. A few small streams have cut gorges 20 yards wide across it at intervals, but there can be no doubt as to its continuity, even though it is not uniform in height. Observed from the sea, it forms one of the most prominent coastal features, though at no place is it more than 100 yards wide and usually only a few feet across. From a height of 125 ft. at Terawhiti it descends to 110 ft. at the head of Oterongu Bay, though this lesser height may be due to slumping of the rocks which are here traversed by an intense shatterbelt. Thence it rises somewhat abruptly to 145 ft. at the east end of Oterongu Bay. For the next mile it continues horizontally, after which it rises gradually in the course of two

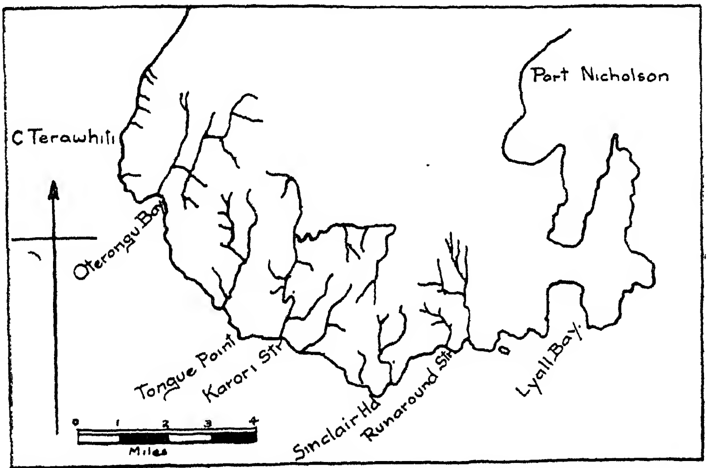

FIG. 2.—Sketch Map of the South Coast, Wellington Peninsula.

miles or so to 270 ft. a little to the west of Tongue Point. It was this change in height that induced Park (1910, p. 586) to say that he had satisfied himself that it was not a marine platform of erosion; but his alternative hypothesis of a glacial origin can hardly be deemed so convincing as the theory that he attempted to overthrow. Throughout its length the platform exhibits the same thin veneer of beach gravels that was noted at Cape Terawhiti. A glance at Plate 75, Figs. 1 and 2 will serve to suggest a relationship between the benches in the two localities and the following of the lower platform continuously from one to the other shows that they are to be correlated in spite of the disparity in height, those at Tongue Point being twice as high as those at Terawhiti.

The Tongue Point platform, undoubtedly the finest west of Port Nicholson, has been described by Cotton (1912, p. 255). Along its base it is over a mile long and it reaches a maximum width of almost half a mile, the height at the rear being 240 ft. As noted by Cotton, even the coarser beds of beach cover attain a maximum thickness of

cnly eight feet. This also bears witness to the strength of a former Cook Strait current. Unlike the other rock platforms, Tongue Point is quite free from any stacks or unconsumed upstanding rock masses. It presents, therefore, a remarkably even surface with an average seaward slope of 5°, which is as yet almost untraversed by streamlets. This may be attributed to the fact that the platform is flanked by two large streams, the Waiariki and the Karori, which effectively drain the country behind the platform so that the only run off is from the surface of the platform itself and the steep cliff at the rear.

At Tongue Point, as at Cape Terawhiti, a second (higher) bench is present at twice the height of the main platform, i.e., at 480 ft. (Plate 75, Fig. 2). It is developed to the same relative extent as that at Terawhiti and although no intervening bench remnant could be found the two must undoubtedly be correlated.

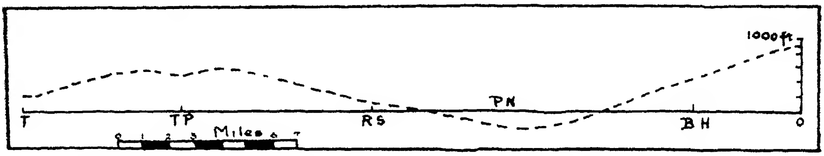

FIG. 3.—To show the height relation of the shoreline of the Tongue Point Cycle (dotted line) to that of the present day.
T. Terawhiti. R.S. Runaround Stream. B.H. Baring Head.
T.P. Tongue Point. P.N. Port Nicholson. O. Orongorongo.

Between Tongue Point and Port Nicholson no other raised marine platforms were observed but most valuable data may be obtained by a consideration of the amount of rejuvenation shown in many of the stream courses. By measuring the heights of the old valley-forms a regular sequence of uplifts was obtained in support of Cotton's "Port Nicholson Warp" theory. Fig. 3, drawn from the above data and showing the relation of the ancient shoreline of the Tongue Point Cycle to that of the present day, demonstrates clearly the nature of the warp as distinct from any faulting. Between Island Bay and Haughton Bay no movement is apparent and then succeeds the drowned region of Lyall Bay and Port Nicholson. The question remains:—Was the Tongue Point shoreline uplifted uniformly (or subuniformly) and subsequently locally downwarped to form Port Nicholson, or was the Port Nicholson district downwarped at the same time as the Tongue Point-Terawhiti coast was arched up? From the fresh appearance of the Wellington Fault Scarp which bounds the depression to the north-west it seems that the drowning movement was separate from and succeeded a more general movement of uplift which concluded the Tongue Point Cycle of erosion. Cotton (1921B, pp. 134-135) inferred, from the fact that the raised marine platforms to the east are parallel or subparallel, that the depression was quite recent. As the present writer is strongly of the opinion that the platforms to the east of Port Nicholson must be correlated with those to the west, and have been produced by the sea during pauses in the same series of movements, discussion of the sequence of orogenic movments is deferred until the Orongorongo platforms have been described.

PORT NICHOLSON TO ORONGORONGO. (6 miles).

About a mile east of Port Nicholson, appear the mouths of two small drowned valleys, both now almost closed by shingle bars. Except for these, the beach is continuous from Port Nicholson to the mouth of the Waiuni-o-mata River, and thence to the Orongorongo. In Fitzroy Bay a raised beach of shingle is present some forty yards from the sea at a height of 20 to 25 ft. Cotton (1921, p. 139) regards this as the pre-1855 storm beach ridge, though it is flat across the top and in places over 25 yards wide. It is thus far too high, wide, regular, and well preserved for a storm beach such as the pre-1855 beach would be. Between the Wainui and Orongorongo rivers, several ancient beach ridges (now confining lagoons on the strand plain) may be recognised but they are not at so uniform a height as their equivalents to the east of the Orongorongo. Along the west bank of the Orongorongo an exposure shows that the 30 ft. level is cut in rock to a considerable width.

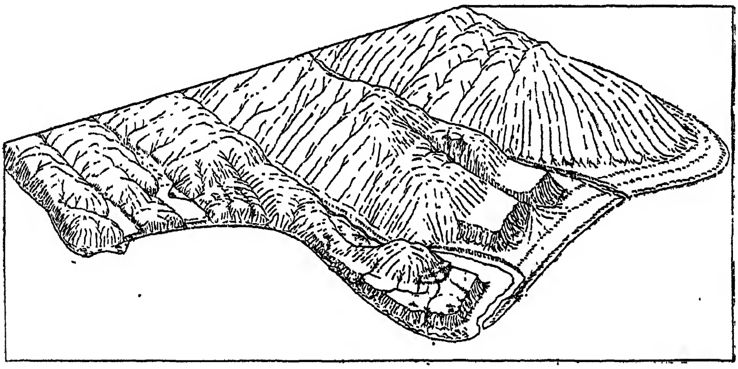

FIG. 4.—Diagram-sketch of the southern end of the tilted area east of Port Nicholson. From left (north-west) to right (south-east) the coastal features shown are: Pencarrow Head, Lake Koangapiripiri, Lake Koangatera, Fitzroy Bay, Baring Head, Wainui-o-mata River, Orongorongo River, Cape Turakirae. (From Cotton).

Throughout its length the beach is backed by high cliffs which exhibit an even crestline formed by the edge of a raised marine terrace. A series of such terraces is present (Cotton, 1921B, p. 135) all tilted to the west, i.e., towards the downwarped Port Nicholson area. These terraces were fully investigated and carefully described by Cotton (*op. cit.*), so little need be repeated here.

A summary of the benches present is, however, given for the sake of continuity and for comparison with other benches recorded in this paper. As all the platforms are tilted to the west, correlation is a matter of detailed field work, and a statement of heights alone is deceptive and misleading. The following are Cotton's determinations and correlations:—

Gollan's Valley to Wainui.	Baring Head.	Wainui to Orongorongo.
——	——	Highest Bench.
——	——	Higher Bench.
Wainui Platform.	——	Orongorongo Platform.
——	Baring Head No. 3.	——
——	Baring Head No. 2	——
——	Main Baring Head Platform.	Continuation of Main Baring Head Platform.

The Baring Head Platform, between the Wainui and Orongorongo rivers, where the covering of waste ranges up to 50 ft. in thickness, is at heights, from west to east, of:—385 ft., 500 ft. and 480 ft., while the Orongorongo Platform above it is at heights of:—760 ft., 890 ft., and 870 ft. These observations were made with an aneroid barometer along the rear edge so that the terraces appear parallel within the limits of observation. Both show a marked drop of 20 ft. at the eastern end.

Comparison of the benches to the east of Port Nicholson with those to the west shows that there are no grounds upon which indisputable correlations can be made, but the following are suggested as probably correct.

Terawhiti.	Tongue Point.	Orongorongo.
Upper Bench, 240 ft.	Upper Bench, 480 ft.	Orongorongo Platform, 890 ft.
Lower Bench, 125 ft.	Lower Bench, 240 ft.	Baring Head Platform, 500 ft.

On this basis the analysis of the earth movements is as follows:—

1. A strand line as represented by the highest bench at Orongorongo is the earliest stage recorded.

2. The second highest bench at the Orongorongo indicates an uplift of the order of 125 ft.

3. The cycle of erosion exemplified in the upper platforms at Terawhiti and Tongue Point, the "Wainui" platform and the "Orongorongo" platform was a well marked one of some duration, separated from 2 above by an uplift of some 50 ft. at Orongorongo.

4 and 5. Two short periods of stillstand are represented by the two small benches at Baring Head. They show that uplifts of 240 ft. and 80 ft. have taken place.

6. The main platforms at Terawhiti and Tongue Point, and the Baring Head platform represent Cotton's Tongue Point Cycle of erosion, which apparently was ushered in by an uplift of not more than 80 ft. near Orongorongo.

7. Uplift, probably as a series of movements, brought the coast to a position a little higher than its present level.
8. The Port Nicholson downwarp.
9. Subsequent slight uplift of a few feet to present level.

All the above estimates of uplifts are for the Orongorongo area, where the maximum movement seems to have taken place. Most of the movements in the past seem to have been tilting to the west, thus suggesting the presence of a hinge-line out in Cook Strait about twelve miles west of Cape Terawhiti.

OROXGORONGO TO LAKE ONOKE. (14 miles).

To the east of the Orongorongo River the fringing plain is broader, until at Cape Turakirae it is over 400 yards wide. Along the west side of Palliser Bay, however, its width diminishes gradually until it is only a few yards across. Throughout much of its length well marked ridges of beach gravel are present, four being visible at the mouth of the Orongorongo at heights of: 12, 22, 32, and 44 ft. above high water mark, although the 12 ft. beach ridge was probably formed by the sea while at its present level. At Cape Turakirae, Aston (1912, p. 209) estimated the heights as 9 ft., 40 ft., 60 ft., 80 ft., and 95 ft., but these values appear to be too large, the height of the last being only 70 ft. In addition to the well-marked ridges of beach gravel the plain is strewn with great boulders ("monoliths" of Aston) in the neighbourhood of the Cape, giving an exceedingly rugged appearance to the surface. Along the greater part of the western Palliser Bay coast a 25 ft. raised gravel beach is prominent, in places backed by remnants of a 50 ft. raised cut rock bench covered with coarse detrital deposits (Plate 76, Fig. 1). In the face of the old sea cliff fronting this platform are several ancient marine caves, some of which have been figured by Cotton (*Geomorphology of N.Z.*, p. 423). This bench is of marine origin but farther north, at the mouth of the Muka Muka Stream, the wide 50 ft. terrace may be partly stream cut. The fine gravels covering it show no distinctive characters.

The uplifted platforms of the Baring Head series have been traced only as far as the west bank of the Orongorongo River. On the east side of the river practically no traces of them can be found. The sudden disappearance of such prominent features of the landscape has proved one of the most baffling problems of the district, especially when it is remembered that the later periods of uplift, represented by the shingle ridges and the coastal plain, are better developed to the east than to the west. No satisfactory explanation of the facts has been presented as yet, nor can one be offered here.

In addition to the 25 ft. gravel beach and the 50 ft. rock bench on the western side of Palliser Bay, the profile of the hills facing the sea is suggestive of a high level terrace with a considerable slope towards the Wairarapa Valley. This series of possibly marine remnants is present in two localities south of the Muka Muka Iti Stream at a height of 510 ft. at 335 ft. on the north side of the Muka Muka Iti, and at 225 ft. at the Muka Muka where there are uncon-

solidated covering beds 30 ft. thick. All these high level terraces are of somewhat doubtful origin but the most probable explanation is that they are marine.

At Eglinton's, in the north-west corner of the Bay, a considerable area is even surfaced but it has too great a slope seaward to appear to be a marine bench. It was probably cut by the Ruamahanga River. On account of the slope the writer could give no estimate of its height. A small flat area facing Lake Onoke may, however, be a continuation of the platform which is so prominent to the east of the Lake.

Lake Onoke to Cape Palliser. (23 miles).

Lake Onoke is protected from the sea by a broad gravel beach or bay bar some two miles long, sometimes continuous from side to side and on other occasions broken by a gap through which the surplus waters of the lake escape. The presence of such an outlet is governed largely by the state of the sea, which throws up gravel to block the passage in times of storm, the outflow from the lake being sufficient to clear a channel in good weather.

To the east, along the head of Palliser Bay, the cliffs, cut in soft Tertiary mudstones (Pliocene to the west and Miocene at the eastern corner), rise in places to 200 ft., but are now usually protected from marine undercutting by a beach of coarse sand which extends without a break from the lake outlet to the north-east corner of the Bay. The material for this beach would appear to be derived from the greywacke rocks which outcrop along both sides of the Bay, though, according to Marshall (1929, p. 345), sand is not usually produced by the wearing of gravel on a beach. From the north-east corner of the Bay to the Waitarangi Stream most of the shore is unprotected by beach deposits and so active cutting back of the soft Tertiaries is now in progress, and the cliffs are retreating at a rapid rate. This recession is measurable at the Waitarangi Woolshed, which was built many years ago at some distance from the sea. Now it is in danger of being engulfed; indeed some of the mustering yards are already fast disappearing, the encroachment having been of the order of 25 ft. in the last six years. This portion of the coast receives the force of the south-westerly gales far more than does the head of the Bay and is also nearer the source of the hard greywacke detritus which supplies the abrasive material, so that erosive action is at a maximum in this locality.

Southward of the Waitarangi Stream a broad, uplifted coastal plain makes its appearance and extends almost continuously along the coast for the next 45 miles to the mouth of the Pahaoa River. In only two places throughout this distance was any evidence found of a rock cut base to the platform, the surface in general being thickly covered with gravel, both marine and alluvial. Shingle fans have been formed by most of the streams debouching from the high country to the east, which rises rapidly to a height of 1000 ft. or more, and these fans cover most of the surface of the coastal plain. (Plate 77, Fig. 1). At Black Rocks Point this platform attains a maximum

width of 400 yards and shows four successive subparallel beach ridges all at about the same height. An uplift of 30 to 35 ft. was apparently responsible for the laying bare of this fringing plain.

Midway between Black Rocks and Cape Palliser, hard Tertiary rocks, apparently not hitherto described, though figured by Hochstetter (*Geologie von Neu Seeland, Novara Exped.*, p. 3), outcrop over a small area, striking N. 20° W. and dipping S.W. 60°. They consist of a basal conglomerate 1 ft. thick of well-rounded pebbles; sandstone 50 to 60 ft.; and an arenaceous limestone, 30 to 40 ft., containing fragments of cirripedes, brachipods, polyzoa, echinoids and corals; but the fossils are too poorly preserved and the matrix is too hard to allow collecting.

At the head of Palliser Bay is an extensive terrace which, broken only by the Whangaimona River and its tributaries, stretches from Lake Ferry to the east side of the Bay, where it is continuous with the platform which is so prominent along that portion of the coast. The terrace is not level but rises from 100 ft. at the east side of Lake Onoke to over 300 ft. at the eastern end. At the rear is an even-crested ridge also ascending eastward until it is comparable with the second platform along the eastern side of the Bay, i.e., at 575 ft. Throughout its length this ridge is unbroken, straight and even-crested. The presence of this ridge precludes any possibility of a river origin for the terrace at the head of the Bay unless it be the work of the Whangaimona River which seems now too small to cut such an extensive terrace, a mile and a half wide and five miles long. Further, a river origin leaves unexplained the straightness of the rear edge. No gravel deposits such as might give a clue to the origin were observed. As both the terrace and the even crestline of the ridge at the rear appear to be the continuations of undoubtedly marine platforms along the east side of the Bay, they may for the present, be considered to have been cut by the sea.

Along the whole of the east side of the Bay a well-preserved series of raised platforms affords probably the most striking feature of the coast. When they are seen from a distance the interrelation of the platforms is not very clear for two reasons: (a) There is a general tilt downwards from the opening of the Bay to its head and (b) The benches have a varying development relative to one another at various points along the distance through which they are found. The main platform rises at a gradient of 25 ft. per mile southward, and the higher ones are also tilted to about the same extent. Although the character of the rocks varies from soft Tertiary mudstones at the north end to the hard Trias-Jura greywacke of the Haurangi Mts. at the south end of the Bay, there is little difference in the stage of development reached by the platform in each case.

The terraces are best developed at the following localities:—

(a). Head of Palliser Bay as already described. The heights at the east end are: Terrace, 300 ft.; Ridge crest, 575 ft.

(b). Just north of Hurupi Creek: 425 ft. and 730 ft.

(c). Behind Waitarangi Station: 460 ft., 545 ft., and 800 ft. The 460 ft. terrace is 200 yards wide, the 545 ft. terrace is clear, but only a few yards wide, both being well cliffed and the third, or 800 ft. bench is also well defined. (Plate 76, Fig. 2).

(d). Te Hamenga Point: The top of the point itself is formed by the second lowest terrace (the lowest being cut away south of Waitarangi) and has a strong tilt along its length, rising from 520 ft. at the stream on the north side to 660 ft. at the Otakoha Stream on the south. At the north end this platform shows very plainly 30 ft. of well-worn, even-graded beach gravel. Other terrace remnants are present at heights of 855 ft. and 965 ft., but well-defined cliffs do not show at the rear. The absence of strong cliffing is due to subaerial weathering, which has rounded the formerly steep slopes, though the line of the ancient cliffs is still distinctly traceable.

(e). Black Rocks Series: The heights of the main platform are: 1. One mile north of Tilson's Whare, 675 ft., with a covering of 20 ft. of marine gravel. 2. Opposite Tilson's Whare, 710 ft. 3. At Black Rocks, where there is a covering of 30 ft. of subangular to rounded gravel, 700 ft. There are also forms suggestive of a higher terrace at approximately 950 ft.

As remnants of the same terrace occur at different heights due to tilting of the platforms, some scheme of correlation becomes necessary. The following table is therefore given:

Black Rocks.	Te Hamenga.	Waitarangi.	Hurupi Creek.	Bay Head.
——	965 ft.	——	——	——
950 ft.	855 ft.	800 ft.	730 ft.	575 ft.
700 ft.	600 ft.	545 ft.	——	——
——	——	460 ft.	425 ft.	300 ft.

Towards the south end the terraces are dissected by numerous streams which have cut gorges some hundreds of feet deep through them. The traversing of such an area becomes extremely arduous as it is necessary to descend to sea level each time in passing from one terrace remnant to another. These mountain streams have transported the waste which now covers the surface of the coastal plain, and, considering that some of them descend almost 3000 ft. in four miles, it will be seen that they are capable of carrying an unusually large quantity of detritus. Some idea of the nature of the country may be obtained from Plate 77, Fig. 2.

Cape Palliser to Pahaoa River. (30 miles).

From Cape Palliser to the Pahaoa River the rocks outcropping on the coast are, almost without exception, the greywacke of the Haurangi Mountain Range, similar to that of the Wellington area. At only a few localities are the younger rocks present, where they are usually represented by flaggy limestones. The observed outcrops of the younger series are:—(1). Opposite White Rock Station. (2). At the mouth of the Opuawe River. (3). At the mouth of the Awhea River, and (4). At the mouth of the Hangaroa River. The age of this limestone is in doubt, though McKay (1879, p. 79) regarded it as the equivalent of the Amuri Limestone. It is certainly Notocene

in age as distinct from the Trias-Jura greywacke. To the south of White Rock Station the effect of the disparity between the two rock types is admirably shown in the topography, the greywacke standing up, bounded by precipices 1500 ft. high, above the rounded, subdued forms produced by subaerial weathering on the younger beds. (Plate 78, Fig. 2).

For almost the whole distance under review the coastline consists of the towering greywacke cliffs fringed by a narrow strip of uplifted rock-and-gravel platform such as has already been described. (Plate 78, Fig. 1). Indeed, for the greater part of its length, this coast is wild and rugged in the extreme. To the north, at the Devil's Mile, the rock, as is not unusal in the greywacke series, is crushed and shattered into "rotten rock," an almost unconsolidated fault breccia, so that the sea now reaches to the base of the cliffs except at low water. At the north end of the "Mile" much "rotten rock" comes down to form a talus slope and fan, the seaward edge of which is now strongly cliffed.

A mile or so to the north of Cape Palliser the coast is strewn with gigantic boulders or "monoliths" similar to those at Cape Turakirae, where the character of the country is in every respect akin to that of the locality just studied.

PAHAOA RIVER TO FLAT POINT. (18 miles).

The rocks between Pahaoa and Flat Point are more varied than those farther south. At the mouth of the Pahaoa (north bank), there is a ridge of limestone and between Pahaoa and Flat Point, outcrops of this and a similar limestone are not infrequent. Notably they are present: (1) on the north bank of the Pahaoa; (2) at the mouth of the Waihingaia Stream, where it is strongly shattered and the fissures are filled with calcite; (3) a few hundred yards north of the Holey Rock Lighthouse, where also it is somewhat crushed; (4) in the hills west of Glenburn Station, where stalagmites have been formed below overhanging cliffs; and (5) near the tip of Flat Point itself, where it stands above the beach deposits as a rugged outcrop. Crawford (1868, p. 17, essay) has also noted:—"At Waikekino, six miles south of Flat Point, reefs of Amphibolite are found on the shore or in the sea, penetrating the above named calcareous rocks, and boulders of various trappean rocks are common in the Kaiwhata and other rivers." In his 1869 report (p. 351) he also referred to "Diallage traversing limestone" at Waikekino. This outcrop was not observed by the writer but pebbles of igneous and dyke rocks are very common along the shore in this locality, though no specimens were seen *in situ*. The specimens found were probably transported down the rivers from outcrops known to exist farther inland, thus accounting for the non-observation of any coastal outcrops, while Crawford's original outcrop being "in the sea" in 1868 may have been since demolished. A highly glauconitic sandstone usually underlies the limestone and was noted at nearly all the outcrops of this rock.

At the mouth of the Pahaoa a 35 ft. terrace is strongly in evidence. From its position it might be regarded as of fluvial origin

but for the fact that well-marked beach ridges of sand, now firmly bound by vegetation, occur regularly across it parallel with the present shoreline. These ridges prove that, though the river may have cut the platform the material now covering it was arranged by the sea prior to and during the uplift of 35 ft. On his visit to the locality the writer could obtain no evidence as to which agency originally cut the bench. At places along this uplifted strand small streams, debouching from ravines in the higher country at the rear, have built shingle fans across the inner edge of the platform. These are quite distinct from the old beach deposits and there can be no doubt that river action had little to do with the present appearance of the strand plain apart from the supplying of waste.

North of the Pahaoa the plain gradually becomes narrower until the sea reaches the base of low cliffs, some of which are cut in shingle fans. A short stretch of sandy beach covered with large dunes succeeds northwards, presumably as a temporary phase in the general cutting back of the shoreline, and then the 30 ft. platform again makes its appearance, either as bare rock or covered with coarse shingle. Beyond the Holey Rock Light it gradually becomes covered with finer material and about two miles south of Glenburn Station is grassed. All along from the Pahaoa to the Waikekino Stream there thus appear indications that the coast has undergone an uplift of 35 ft., that is, a definite movement of the strand has taken place. The coast north of this point, i.e., the Waikekino Stream, though presenting a strand plain, the inner edge of which is about 35 ft. above sea level, shows no definite evidence of uplift, as sand will easily form dunes 35 ft. above high-water mark. Rock outcrops are not found on its surface, and, as distinct from a plain composed of solid rock with only a comparatively thin covering of soil, the whole coast has the appearance of a strand prograded merely by the accumulation of waste governed by marine agencies. (Plate 79, Fig. 1). It presents a fine beach, inland from which much of the surface is covered either by traces of successive beach ridges or great wandering sand dunes, which, over much of the surface, especially at the north end, have obliterated all trace of the regular ridges, and, finally, the swales between many of the later-formed beach ridges are sometimes marshy. The coast immediately to the south, however, shows no good beach and is a rock bench, either bare or only thinly covered with coarse gravel; a surface from which moisture drains away almost immediately.

The peculiarity of this short stretch of nine miles or so lies in the fact that it has prograded a distance of 500 yards although the coast to the south is subjected to extremely active marine erosion which must have been wearing and cutting the coast for a very long period, producing towering cliffs behind the fringing plain; and to the north the sea now reaches (beyond the Kaiwhata) to the foot of 150 ft. cliffs which are being rapidly worn back. Flat Point itself forms the northern end of the prograded section of the coast but is not sufficiently prominent to deflect coastwise currents and form a backwater in which waste derived from the rest of the coast might accumulate, indeed the point itself is mainly of a prograded nature.

A prominent terrace is continuous at about 500 ft. almost all the way from Glenburn to Flat Point. (Plate 79, Fig. 2). The most southerly remnants may be observed near the Holey Rock Light where they are at a height of 450 ft. and are capped with well-sorted, stratified marine gravel. Towards Glenburn the remnants become more prominent and continuous, and the rear edge rises gradually to 470 ft. North of Glenburn Station there can be no doubt of the continuity of the platform, though small streams cross it in deep ravines. Stratified gravel deposits cap it a mile to the south of Flat Point, where the height is 490 ft. At Flat Point it is approximately 500 ft. and three-quarters of a mile wide but is dissected almost parallel to the coast by two large stream valleys, while at its seaward edge it is cut off by the steep cliffs at the rear of the prograded Glenburn–Flat Point beach. Northward it descends somewhat and grades into the 450 ft. levels at the Kaiwhata.

The origin of the stream-valleys now almost parallel to the coast and dissecting the platform along its length is of interest, as to-day the terrace still slopes seaward. It seems that they must be subsequent as they are parallel to the strike of the country and opposed to the slope of the plain. They flow into a stream which crosses the plain in an almost straight line from the hills to the sea.

FLAT POINT TO THE WHAREAMA RIVER. (16 miles).

The rocks along the coast from Flat Point to the Whareama River are, almost without exception, soft sandstones and mudstones of Middle Tertiary age, usually in alternating bands about 6 inches thick. These present but little resistance to marine and subaerial agencies, both of which are actively engaged in wearing back the coastline at a rapid rate. So non-resistant are the rocks generally, that it is rare to find a well-developed platform at the base of the cliffs, or a distinct nip where storm waves are most active.

North of Flat Point the prograded coastline abruptly changes to one where rapid cutting back is in progress, and for four miles towards the mouth of the Kaiwhata River a steep beach of boulders is encountered. Just south of the Kaiwhata the cliffs are being attacked and this phase is then continuous as far as Uriti Point, seven miles to the north. Pebbles of igneous rock occurring among the dune deposits at the point are well rounded, indicating that they have travelled a long distance, and as no outcrop of any such rock was found on or near the coast in this locality, this conclusion is strengthened. From Uriti Point onward to the Whareama a well-developed sandy beach is in evidence, at the south end it is fine and hard, at the north coarse and very soft.

At or near the mouth of the Kaiwhata River an extensive series of raised terraces is developed, some of river and some of marine origin.

(1) At 8 ft.—This terrace is merely produced by lateral erosion on the part of the river and there is no evidence that it represents a period of standstill of the strandline. It is poorly developed.

(2) At 30 ft.—This terrace is well exhibited for 600 yards up the stream and its presence on both banks shows that it was originally

of river origin and cut during a period of standstill; for it must be impossible for the sea to cut a terrace only 120 yards wide at the mouth and penetrating 600 yards inland, cut, moreover, not along a weak band in the country rock, but at right angles to the strike of the beds. This terrace is now covered by 4 ft. of marine gravel, above which is 5 ft. of fine deposit crowded with Recent marine molluscan shells, mostly in a good state of preservation, showing that the bench must have been submerged after it was cut by the river.

Further evidence of this submergence is afforded by a mudstone of recent origin, almost certainly contemporaneous with the marine conglomerate and covering beds of the Kaiwhata 30 ft. bench, and crowded with marine mollusca of recent species which outcrops for a short distance up the next four creeks to the north of the Kaiwhata. The outcrops become smaller and smaller towards the north. The most striking evidence of submergence, however, was disclosed on the occasion of the writer's second visit to the district. Great changes had occurred about the mouth of the river. On the first visit it was easy to cross dry shod by means of a high storm beach of gravel thrown up by the sea which damned the river to produce a lake 75 yards wide and 600 yards long; the outflow from which seeped through the gravel to the sea. On the second visit the river mouth was open to the sea. Owing to much rain in the back country the river had broken the dam and built a temporary bar (about awash at high water) 30 yards seaward of the previous high tide mark. Inside the area thus enclosed the river had exercised a scouring action and disclosed the trunks of 22 trees, all upright in the position of growth, previously covered by the sea and marine gravel, just seaward of the beach. That these trees were actually in the position of growth is shown by the fact that many were slender tree ferns without spreading roots, so that if overturned, they would not subsequently regain the vertical position. Another tree stump, which, though not protected by the bar, had been uncovered by the outwash, and overturned by the force of the waves, was also found to the north.

Still other trees with their roots in ancient soil on the Middle Tertiary mudstones projected up through the Kaiwhata conglomerate into the covering shelly beds. (Plate 80, Fig. 1). These are apparently of an age quite distinct from that of the stumps described above, and the oscillations of the strand in this locality, as represented by the two sets of trees, the 30 ft. bench and beds, and the modern shore appear to be:—

(a) The Middle Tertiary rocks were planed by the river and the upper set of trees grew on the area so planed.

(b) Subsidence of ten feet or so during which the Kaiwhata conglomerate and overlying beds with marine shells were deposited.

(c) Uplift of 25 ft. when a marine bench was cut in the soft Tertiary rocks.

(d) Further uplift when trees grew on the bench so cut.

(e) Depression of 2 or 3 ft. more than the previous uplift so that the trees then growing are now below sea level.

Half a mile farther north, at the mouth of a small unnamed creek three more tree trunks (tree ferns), the roots of which are now

below sea level, were exposed by a fresh coming down the creek. It seems impossible that these tree ferns could be in other than their position of growth, for otherwise they would not be standing upright.

(3) and (4) At 42 ft. and 100 ft.—Both of these terraces are confined to the south side of the valley and were almost certainly produced by lateral erosion on the part of the stream.

(5) On the south side a terrace is present at 240 ft. and on the north side at 180 ft. The slope on each of these terraces suggests that they are one and the same, and that northward the 180 ft. level grades into and forms the 150 ft. level of the Homewood area. Thus near the Kaiwhata the platform appears to be tilted with a slope down towards the north.

(6) At 450 ft.—Here a flight of terraces, now strongly dissected, is present tilted in the same manner as the lower bench, so that, on the evidence available, it seems that this terrace is the continuation of the 500 ft. Flat Point terrace, and that it slopes down northward to form the 350 ft. Homewood level.*

In the Homewood District flat terraces are present at various levels over a distance of eight miles, from the Kaiwhata to the Orui River, and their breadth throughout much of the distance is over two miles. Streams crossing the lower marine terraces have cut broad flat valleys (up to half a mile wide), between which are left the older flat interfluves giving a most complicated series of levels when viewed for the first time. Some of the terraces (the higher levels) are almost certainly marine but the lowest or 30 ft. is undoubtedly of river origin, as will be shown later.

The coastline itself, as before mentioned (p. 510), is now being actively cut back by the sea; the soft Tertiary strata being too incoherent for much undercutting to occur. Slips are frequent, the material being removed by the sea almost as fast as it is supplied. In view of this rapid present-day retreat of the cliffs, the question arises as to what agency or accident has preserved such a wide terrace (two miles wide) along the coast immediately to the rear, for it seems that unless the uplift of 150 ft. was very recent the whole of the terrace should now be cut away. Furthermore, to the north towards Orui, the 150 ft. level is absent but the 350 ft. and 220 ft. platforms, which are not notably developed in the Homewood area, are well exhibited. The explanation apparently lies in the structure of the country.

The rocks strike N.E. and dip inland at angles of 20° to 30°, while the trend of the coast is almost N.E., so that the rocks run out at a slight angle with the coast. Also a reef of very hard rock projects from the headland just to the south of the Kaiwhata mouth. Owing to the state of the sea and tide the writer did not find it possible to examine the reef, but the probability is that it is a hard shell limestone. This reef in former days must have presented a very strong barrier to the sea, as the reef at Castle Point does now, and, although, geologically speaking, such a feature is of only a most

*The name Homewood area is here applied to all that district which lies between the Kaiwhata and Uriti Point.

temporary nature, yet it is certain to leave some effects that will be apparent for a short period after its destruction and it is probably due to the existence of this reef that the erosion of the 150 ft. platform at Homewood has been so long delayed. To the north it is farther from the land (about half a mile to seaward opposite Homewood Station), and as we proceed northward it recedes progressively from the present shore. This is to be expected as that portion would be earlier exposed on the coast and would be attacked first. Thus at Orui, the remnants of the reef are two miles from the shore, and rapid cliff retreat from this former position has completely destroyed the 150 ft. level. The reef may also have aided in the preservation of the 350 and 220 ft. benches when the 150 ft. platform was originally cut at Orui. To-day all that remains of the reef is a few small, upstanding rocks or reefs awash at high water, stretching along the strike of the main reef at the Kaiwhata, and becoming less and less pronounced farther north. In its day, however, it must have presented to the sea a magnificent front similar to that now shown on a smaller scale by the reef at Castle Point.

Furthermore, as will be shown later, a pronounced 30 ft. terrace is present as broad flood plains up all the streams of any size in the district. For all the stream beds to exhibit such marked accordance of a former level, which is so remarkably developed, requires a period of standstill of the strand to be postulated. If such is the case, why is there no record of a marine bench at that height in the district, though such is present further south? If we assume, as indeed there is every reason for so doing, that the sea was engaged at that particular time in cutting back a cliff of hard limestone which retarded its advance very considerably, then the absence of any pronounced bench is accounted for. Since that time it has had only soft Tertiary strata to erode and so has obliterated with ease any marine traces of a period of standstill.

Synopsis of the Terraces in the Homewood and Orui Districts.

(1) At 30 ft.—The terraces in this group are of undoubted river origin. They do not appear as a continuous platform but as a number of flat areas sunk in the general 150 ft. terrace. In plan they are usually horse-shoe shaped, with the open end to the sea. This shape alone makes it practically certain that they are to be ascribed to lateral planation by streams, and not to marine agencies, as the tendency of the sea is to straighten a coastline and not to cut a mile into the land at one place and leave the neighbouring portion untouched, especially when the strike of the rocks is almost parallel to the coast. Moreover, streams in entrenched courses now flow across these plains of lateral planation.

For all the streams to exhibit this 30 ft. plain requires a considerable period of standstill, as many of these basin-like flats are half a mile wide and penetrate a mile or so inland. In some cases two of these plains have coalesced, some distance from the sea, by one stream or other cutting through the interfluve. Both streams, however, still enter the sea on opposite sides of the remaining interfluve

downstream. For this to occur without actual stream capture taking place, both the adjacent plains of planation must have been at exactly the same level when the interfluve was broken down, and the river which obliterated the interfluve must have swung back across its own plain, unless, after capture, the streams separated again. Thus, three miles north of Homewood Station, a broad flood plain is crossed by two rivers which pass to the sea on opposite sides of a remnant of upstanding divide between their mouths, though upstream they appear to flow on the same flood plain. As these remnants are themselves flat-topped (forming part of a higher bench), the effect is to give "hills of planation" somewhat analogous to those described by Gilbert (1877, p. 130). A difference arises in that the flat top on the New Zealand examples may be attributed to marine action in place of normal river planation, the lower, surrounding plain being due to river action alone. These hills are about 50 ft. high (the seaward edge of the older terrace being approximately 70 ft., and the river plain 30 ft.), and form a peculiar feature possible only under the exceptional circumstances described.

The questions arise:—1. Are the higher platforms also plains of lateral river planation? 2. May some of the terraces in other areas be also due to river corrasion?

1. Such forms, when well-developed, may simulate marine terraces so closely as to be indistinguishable and yet the height of a marine bench must be measured at the rear edge, i.e., at the base of the former cliffs, if such are present, while that of a plain of river origin must be taken as near to the sea as possible. Altogether, the problem seems so important that a special section will later be devoted to it (see Appendix p. 520).

2. So far as the raised platforms dealt with in this paper are concerned, the writer considers the 30 ft. Homewood level the only one of undoubted river origin though several others may be taken as of a similar nature.

(2) At 150 ft.—A prominent terrace extends from the Kaiwhata nearly to Uriti Point. This is the widest of all the platforms present, reaching a breadth of over two miles; and, except where crossed by streams and their flood plains, it now reaches the sea-shore; the present cliffs being contraposed in it. The origin of this terrace is somewhat in doubt. The cliffs at the rear are not sharp but are, nevertheless, clearly defined. They are not straight in plan, however, and their general appearance suggests that they were cut by rivers emerging from gorges in the higher terraces. The possibility of such an extensive terrace being cut by small streams is a doubtful point, and the gravels found upon it hardly contribute any definite evidence, though inclining to an alluvial appearance with a suggestion of imbricated structure in an exposure at the side of the road near Uriti Point. The capability of the small rivers which exist in the locality to plane off such a bench is more than doubtful, and the fact that (except for the sharp upwarp at the Kaiwhata end) the inner edge is level for about five miles suggests a marine origin. In the absence of definite evidence the writer inclines to the belief that it is marine.

(3) At 220 ft.—A series of terrace remnants was observed behind the 150 ft. terrace about midway between Homewood and Uriti Point, and an extensive though somewhat dissected platform is present between the Homewood Road and the Orui River. The line of cliffs at the rear is sharp and clearly marked, but the gravel cover is usually obscure. On its general appearance it is classed as marine.

(4) At 350 ft.—In the Homewood District fourteen terrace remnants occur at heights of about 350 ft. Though, owing to the strong dissection of the country, all were not examined, many showed in places a covering of marine gravel similar to that visible on the coast to-day. The deposits range up to ten feet in thickness, and the individual pebbles up to one inch in diameter. Altogether, the alignment of the rear portions and their correspondence in height, together with the character of the gravels seem to indicate a marine origin. At the Orui end, the 350 ft. bench is exhibited as a broad flat top on the hills behind the 220 ft. platform. Like the 220 ft. it is better developed here than at Homewood and it may be here also be regarded as marine.

WHAREAMA RIVER TO OKAU. (20 miles).

North of the Whareama River, to Castle Point, the soft Plio-Miocene strata (alternating mudstone and sandstone bands a few inches in thickness) outcrop along the coast, forming a series of low cliffs at the foot of most of which is a fringe of present day beach. In many localities there is a prominent " 'tween tide " rock platform which is left bare at low water and forms a flat area crossed by slightly raised bands where relatively harder layers outcrop. These " between tide " platforms are sometimes well developed and form a notable feature of this section of the coast. Their prominence may perhaps be attributed to the lack of angular waste with which the sea could abrade them. Another noticeable feature which may also be attributed to the lack of hard waste is that the cliffs are commonly less steep than when cut in hard greywacke. With the reduced cliff-cutting efficiency of the sea, and its lag in abrading the bottom, due to the lack of suitable waste before referred to, subaerial weathering becomes more important, and so the cliffs crumble and the angle is prevented from being steepened, while the sea merely pulverises the soft clayey detritus and removes it.

Just to the south of Castle Point, the " 'tween tide " platforms are not present but they reappear to the north between Castle Point and Whakataki where the strata can be observed running out on them at a small angle with the coast. A sand beach is also present. To the north of Whakataki, the rock platforms become more prominent than ever and the outcrops in them afford a splendid opportunity for unravelling the structure of the country. (Plate 80, Fig. 2).

Midway between the Whareama and Castle Point is an extensive flat area, in places over half a mile wide and 5½ miles long. This may be called the Otahome Flat, after the homestead of that name on it. Though it forms such a prominent feature of the landscape, its origin is a matter of considerable doubt. The only drainage con-

sists of a few small creeks, and the nearest river (the Whareama) is separated from it by a considerable range of hills (the Trooper) in which there is no break to suggest that the river ever flowed nearer Otahome than it does now. Thus a fluvial origin seems out of the question.

On the other hand, the surface, which slopes longitudinally northward from 160 ft. at the Otahome homestead to 90 ft. at its last appearance 1½ miles south of Castle Point, is not sufficiently level to be a plain of marine erosion. Furthermore, no trace of marine gravel has been found upon it. (This, however, may be attributed to the softness of the rocks, the absence of typical beach deposits being merely due to the rock crumbling, instead of forming pebbles, and giving a deposit now indistinguishable from residual clay produced by subaerial weathering). Again, there is a noticeable absence of cliffs, or any suggestion of cliffing, at the rear of the platform. Once more this may be attributed to the softness of the country rock, which rapidly disintegrates with the loss of all bold lines in the topography and the production of rounded contours. There is thus considerable difficulty in determining the origin of the Flat, but for the present it may be regarded as marine.

At Castle Point a number of even crested ridges occur but there is no justification for attributing their form to marine agencies, especially as their heights are discordant.

The lighthouse reef at Castle Point is of interest, not only as a fossil locality, but also as a physiographic study. The structure is simple. The Plio-Miocene sedimentaries run out at small angle with the coast and dip inland at 15°. A hard band of limestone has produced a resistant barrier to the sea and caps a small sea cliff which rises northward. At the north end arenaceous deposits form the uppermost layer (on which the lighthouse is built) but at the seaward edge these have been cut away by the spray which dashes with great violence against them as the waves strike the limestone below. A stripped upper surface is thus produced on the limestone which therefore stands seaward as a platform sloping slightly inland. Behind the reef is a lagoon, which has an opening to the sea at the south end, where the limestone stratum inclines down towards sea level. Along the outer margin of the reef the finest marine views on the coast may be obtained in rough weather, the sea dashing with great violence against the almost vertical surface of the limestone and hurling spray high in the air against the arenaceous deposits behind. Beneath the lighthouse a large cave pierces completely through the reef. Due to percolating waters much travertine has been deposited in it and small stalactites hang from projections on the roof.

It requires little imagination to visualise a reef such as this, on a much grander scale, previously protecting the Homewood coast north of the Kaiwhata; and the existence of such a reef in former times in that region has already been discussed.

For some distance along the Matai Kona Road, north of Whakataki, a series of roughly stratified sand deposits containing Recent marine Mollusca occurs. They may possibly represent a period of

standstill when the strand was 50 ft. higher than now or may be correlated with the Recent mudstone deposits and Kaiwhata conglomerate of the Homewood area. In the latter case the movement may have been almost uniform along the coast and the intervening evidence eroded away. There is, however, no definite basis of correlation.

The Correlation of Platforms in Different Areas.

It seems advisable here, in view of the fact that excellent suites of platforms occur only in widely separated localities, to give a summary of the bases on which these suites may best be correlated, if any such correlation is possible.

1. *Similarity in height.*—If uplift movements were uniform from place to place it would be possible to correlate benches in different localities on the evidence of height alone. Furthermore, if only a slight tilt or warp is present, and the sets of benches not very far apart, calculations of slopes and gradients can be used as a basis of correlation. This method was employed herein with the benches along the east side of Palliser Bay where the gaps between sets of terraces are not great and where all the terraces have a general slope to the north. It is frequently necessary, however, to treat each platform in one vertical set separately to allow for the effects of warping or tilting in between the various stages. This method has proved of great service when employed over limited areas but is insufficient in itself when applied to benches in widely separated localities.

Jobberns (1928) in his study of the north-east coast of the South Island, found practically continuous marine terraces for considerable distances along the coast at almost constant elevation and used a pure height correlation very extensively in comparing benches in different areas. It must be emphasised, however, that his is an exceptional case and well supported by field evidence of almost strictly uniform uplift. In the southern portion of the North Island benches are rarely found parallel to sea level but are strongly tilted and warped. Any correlation based on actual height is therefore not only useless but misleading.

Henderson (1924, p. 589) bases most of his correlations purely on height data, and divides the benches of the New Zealand coast into four groups: (a) Awakino Cycle, up to 120 ft.; (b) Tongue Point Cycle, 200-300 ft.; (c) Charleston Cycle, 350-600 ft., and (d) Kaukau Cycle, above 600 ft.

This arbitrary division on such a basis, though it may be true in a broad sense for New Zealand as a whole, cannot be applied to a limited area because a continuous tilted platform may, at one extremity, fall well within the limits of one group and at the other end be quite as definitely comparable in height with the representatives of a much younger or older cycle. Thus Terawhiti 125 ft. platform would approach most closely the Awakino Cycle, while the Tongue Point 240 ft. platform, a continuation of the Terawhiti platform, is actually the type locality of the earlier Tongue Point Cycle; also the second Terawhiti remnant (250 ft.) is, according to the height correlation, of Tongue Point age, but its equivalent, the

Tongue Point upper remnant is 480 ft., and therefore to be classed with the Charleston platforms. Again, the main platform of the east side of Palliser Bay is, at its southern extremity, 700 ft., and therefore should be equivalent to the Kaukau Cycle, while at Te Hamenga and Waitarangi it is 600 ft. and 545 ft. respectively, thus being definitely within the limits of the Charleston Cycle.

It seems, then, that strict correlation of platforms on the basis of height alone is attended by very grave dangers of error. Admitting that in the broad sense New Zealand has moved as a whole during late Tertiary and Recent times, yet differential movement has also been strong in some localities, and the complications arising from the correlation of benches which, though at similar levels, are nevertheless of different age are likely to become formidable if height data are relied upon exclusively.

Furthermore, many of the earlier estimates of terrace levels are merely eye measurements, and it is extraordinarily difficult, even with constant practice, to judge the heights of terraces with any degree of accuracy. Jobberns (1928, p. 531) records an instance where an estimated height (by Hutton) was "only a little more than half the actual height." McKay also erred in the same direction in his estimates of the Palliser Bay benches. In consequence, therefore, of the excessive warping and tilting of the platforms under review no correlations on height alone are attempted here.

2. *Similarity in stages of development and appearance.*—In some cases this forms a very reliable guide for the classification of terraces. A better example could hardly be found than the profiles of Terawhiti and Tongue Point. In spite of the disparity in heights previously referred to, a comparison of the profiles renders correlation almost certain, and in this case there is the continuous presence of the lower platform between the two points to place the identity beyond doubt. It was found in the field that by this method, the comparison of sets of benches was not only much simplified but also fairly reliable. The relative extent of successive terraces, combined with their relative heights, gives a general impression of them which is of the utmost value for correlative purposes. A precaution which must be observed lies in noting the geological structure of the country, as in different sets of beds quite different appearances may be assumed by the same platform. Notably the ratio of height to width varies.

3. *The covering beds.*—In some instances a characteristic rock type may be found among the deposits on a certain bench but not on the terraces either above or below. Fragments of rotted pumice, for example, may be frequently found on a particular terrace and so provide a guide to the correlation of platforms in neighbouring areas. As a general rule, however, the character of the rocks and pebbles forming the cover varies so considerably (a) with the distance transported and (b) with the rock of which they are composed that a small distance may be responsible for a great change in the type of cover, especially when the beds were deposited close to the supply of waste.

A tentative correlation of the benches of the South Coast is here given. In each case two benches are very prominent, all others being

distinctly subsidiary, and in every locality the lower of the two more prominent platforms is the better developed. They are therefore taken as the basis of correlation from district to district.

Terawhiti.	Tongue Point.	Baring Head.	Orongo-rongo.	Black Rocks.
——	——	——	1100 ft.	——
——	——	——	925 ft.	965 ft.*
250 ft.	480 ft.	760 ft.	870 ft.	950 ft.
——	——	Two small terraces.	——	——
125 ft.	240 ft.	385 ft.	480 ft.	700 ft.

From this it will be seen that the two main terraces, which are found in each case, correlate fairly well, rising in each instance the farther east that they appear, suggesting a general axis of tilting somewhere in Cook Strait. Just as the Tongue Point shoreline is downwarped in Port Nicholson at the present day, so, apparently, there was warping between previous uplifts producing slight anomalies in the relative heights. In every case the platforms are carved in hard greywacke.

The terraces of the Homewood area, excavated in soft Tertiary strata, present features not comparable with those cut in greywacke and have been already correlated among themselves so that no attempt is made as yet to compare their various ages with those of the greywacke suite.

Correlation of lower raised beaches.

Beaches at 25 ft. to 35 ft.—This is present from Baring Head to Orongorongo, whence it follows around Cape Turakirae and appears as the wide 25 ft. beach along the west side of Palliser Bay. Where the Tertiary rocks outcrop at the head of the Bay it is now entirely cut away by the sea operating at its present level, but is prominent farther on as the 35 ft. uplifted plain fringing the coast from Waitarangi to the Pahaoa. Farther north, it is probably represented in part by the prograded coast south of Flat Point and then by the 30 ft. uplift at Homewood and the Kaiwhata. Thus one of the latest movements of the coast appears to have been a general uplift of approximately 30 ft. throughout almost the whole length of coast described in this paper.

Appendix.

Criteria for the Determination of Marine or Alluvial Origins.

In any discussion involving quantitative estimations of uplift, the origin of the particular terrace on which calculations are based must of necessity be one of the most important points to be deter-

*The 965 ft. bench is not at Black Rocks but at Te Hamenga; this is equivalent to a height of 1060 ft. at Black Rocks Point.

Fig. 1.—Terawhiti showing (in profile) the remnants of two marine terraces.

Fig. 2.—Tongue Point (profile). Compare with Fig. 1.

Fig. 1.—The 25 ft. shingle beach (enclosing lagoon), 50 ft. rock bench, and possible 510 ft., remnant western Palliser Bay.

Fig. 2.—The 460 ft., 545 ft. (on right) and 800 ft. levels at Waitarangi, east side Palliser Bay, looking north.

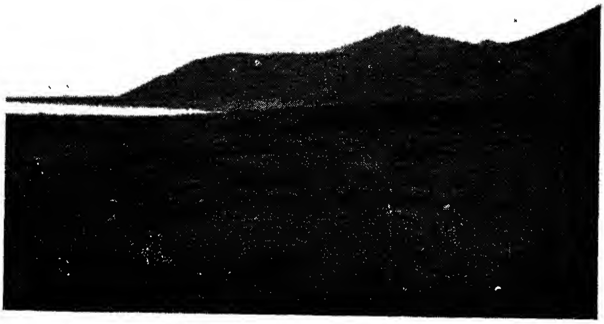

FIG. 1.—The fan-covered surface of the 35 ft. beach north of Black Rocks. Te Hamenga in the distance.

FIG. 2.—Showing the dissection of the 675 ft. terrace opposite Tilson's Whare. The gullies are 650 ft. deep.

FIG. 1.—The 35 ft. bench, looking north from Cape Palliser. The cliffs at the rear are nearly 1000 ft. high.

FIG. 2.—Tertiary (subdued forms) Mesozoic (strong relief) contact south of White Rock.

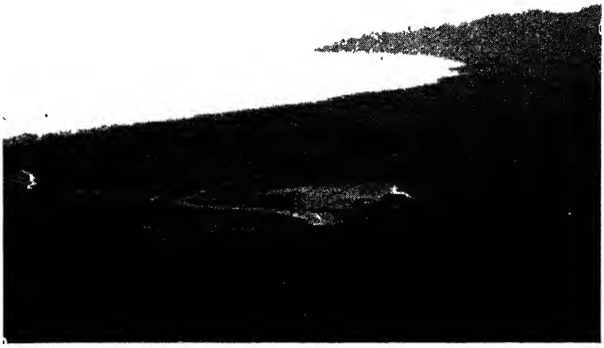

FIG. 1.—The prograded coast south of Flat Point, from the 500 ft. terrace, looking south.

FIG. 2.—30 ft. uplifted coastal plain near Glenburn, showing also the 500 ft. platform from Glenburn to Flat Point.

FIG. 1.—Upper old land surface as shown by trees at the mouth of the Kaiwhata.

FIG. 2.—"Tween-tide" rock platforms north of Whakataki.

mined, for, in the case of a marine terrace the previous shoreline must have been at the rear edge of the terrace, where a line of cliffs may or may not be present; whereas an alluvial plain must be measured at its seaward edge for the bed of a stream near the sea is practically at sea level and if the stream be well graded, as indeed it must be to produce a plain of any dimensions, then we may take that height nearest the sea as giving us the best measure of uplift. To quote an instance: the platform at Homewood whose height has been given in a previous section as 30 ft. has a height at the rear edge of 100 ft. Thus if, by any mischance, it were classed as of marine origin, then the uplift represented would be over three times the real measurement. The importance, then, of correct determinations cannot be over-estimated and it is with the object of explaining the criteria employed in the field work for the present paper that the following remarks are appended.

1. *General appearance, extent, position and relative proportions of the terrace.*—These are all *qualities* to be observed from one suitable standpoint, and usually provide the strongest impressions that one receives. The surface must be considered, whether it is even or irregular, whether any irregularity is due to unconsumed stacks, to slipping of the covering beds, or to disused stream channels. A finely sinuous rear edge to a terrace may be taken as indicative of a river origin just as a straight or gently curved one implies a marine origin. In this connection it should be noted that the inner edge of an uplifted terrace is commonly rather more embayed than is the later coastline. Generally speaking, the greater the distance along a coast through which a terrace extends the greater are the possibilities that it is marine, as few New Zealand rivers flow parallel to the coast for a considerable distance. Broad terraces facing the sea near the mouths of even small rivers are always open to grave doubt, especially if no terraces are found farther along the coast, for, though originally cut by one agency, they may be subsequently modified with ease by the other.

2. *Character and distribution of the covering deposits.*—Discoidal gravels are not always found in beach deposits, indeed they are exceptional, but beach gravels are commonly better sorted and less bound together with fine material than are their alluvial equivalents and with practice a nice discrimination between the two types can be made in the field. Apart from the composition of covering deposits much information may be obtained from a consideration of their distribution. For example, at the mouth of the Conway River, South Marlborough, the terrace now uplifted 40 ft. above high water mark is crossed parallel to the present shoreline by a series of gravel ridges formed during the retreat of the sea and proving the marine origin of the terrace. (Jobberns, 1928, p. 532). The remains of former dune deposits may also throw light on earlier shorelines. If the character of the gravel only is relied on, it must be borne in mind that a bench may be river cut, depressed and covered by marine gravel.

3. *The slope of the rear edge of the terrace.*—No river cut terrace will exhibit a perfectly level inner edge if followed along parallel

to the coast, unless it has been tilted back through exactly the angle at which it was cut. This case is extremely improbable, and so level terraces must be, almost without exception, marine.

4. *Presence or absence of cliffing at the rear.*—Good cliffing seems to be more characteristic of the marine type, though river cut terraces sometimes exhibit quite sharp cliffs.

5. *Presence of "island" interfluves,* as described earlier in this paper, is always indicative of a stream origin, on an uplifted coast.

6. *Marine shells* have been recorded from some raised coastal terraces though they are not of frequent occurrence.

Conclusion.

Broadly speaking, the coastline, throughout the length examined, is a coastline of emergence, the only exceptions being Port Nicholson (a local downwarp) and Palliser Bay (a fault angle depression). Along much of the distance uplifted terraces of undoubted marine origin testify to the amount of uplift from place to place and demonstrate that the movements were not uniform but consisted of a series of interstage warpings and tiltings. Small movements of subsidence have also taken place within comparatively recent times at the Kaiwhata and may have affected other regions, but no definite evidence in support of a general lowering of the land was obtained.

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Physiographic Features of the Lower Cascade Valley and the Cascade Plateau, South Westland.

By F. J. Turner, Otago University.

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Contents.

Outline of Topography.

The area under discussion is a belt of rugged hill and mountain country in southern Westland, lying between the Arawata, Jackson and Cascade Rivers, and bordered on the north by the sea coast. It has twice been visited by the writer during the last two summers, when the following observations were made.

Of the three rivers mentioned above, the Arawata is the largest, swiftest and most formidable. It heads against the Main Divide among the glaciers and ice-fields of the Barrier Range, and the high country in the vicinity of Mt. Aspiring. Its tributary, the Jackson, rises at the north-eastern end of the Olivine Range on the slopes of Mt. Collyer, and, for the greater part of its extent, follows a rectilinear north-easterly course to the Arawata, which it joins about five miles in from the sea.

The Cascade is also a large, swift river, but normally does not carry as much water as the Arawata, since its source lies west of the Main Divide in the vicinity of Red Mountain, where the permanent ice-fields are not so extensive as further east. The river flows through a series of steep-walled gorges with a well marked, general north-easterly trend, which is especially pronounced for a distance of eight or ten miles below McKay Creek, where it continues the north-easterly line of the Jackson Valley. Twelve miles above its mouth the river emerges from the gorge between the Olivine and Hope-Blue River Range and, swinging abruptly through a great bend of 90°, follows a meandering north-westerly course down a wide, alluviated valley to the sea (Pl. 81, Fig. 3; Pl. 82, Fig. 4). Its three tributaries —Martyr, Woodhen and McKay Creeks—occupy deep and precipitous gorges which dissect the western slopes of the Olivine Range (Pl. 81, Fig. 2; Pl. 82, Fig. 5).

This latter is the chief mountain range of the district. It branches in a north-easterly direction from the north end of the Humboldt and the south end of the Barrier Range, and for many miles constitutes the watershed between the Cascade and Arawata Rivers. At its southern end the peaks attain a height of 7,000 ft., but further north-east the range seldom rises much above 5,500 ft. The south-eastern sides and summit of the Olivine Range consist of chlorite-epidote-albite-schist and quartz-muscovite-schist similar to the

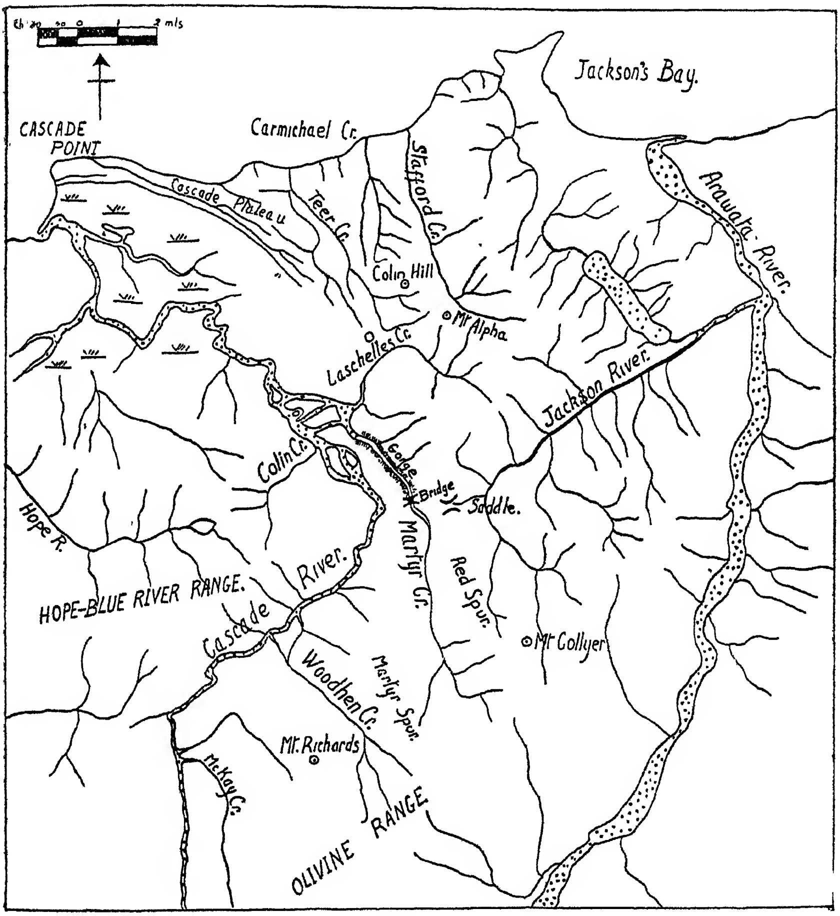


FIG. 1.

Map of the middle and lower portions of the Cascade and Arawata Valleys.

schists of Central Otago, but its western slopes are carved in the great intrusive mass of peridotite which extends from the Jackson River in the north to Red Mountain and the Red Hill Range in north-west Southland (Turner, 1930).

The Hope-Blue River Range, which lies west of the middle portion of the Cascade Valley and parallel with the Olivine Range, constitutes a belt of densely forested country rising to a little above

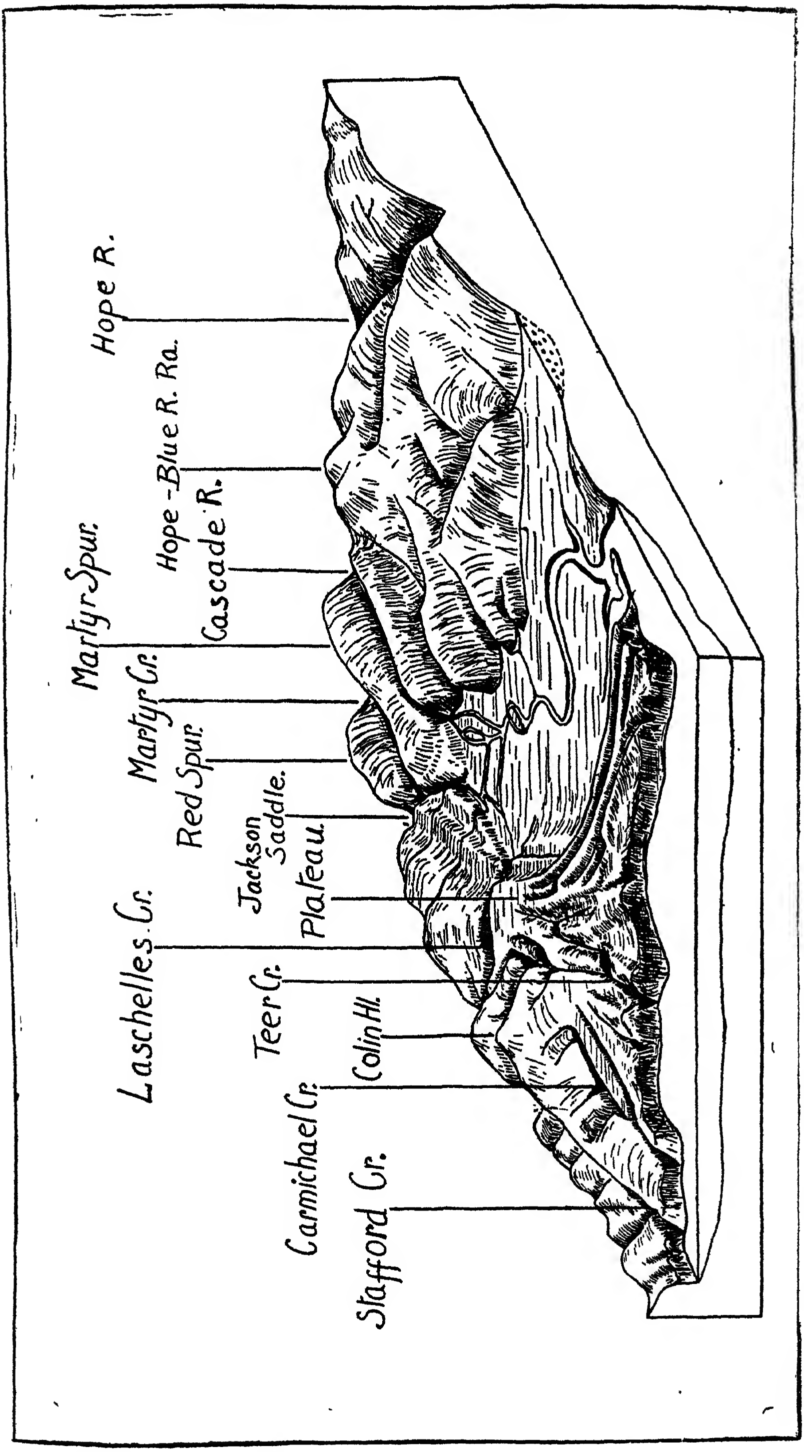


FIG. 2.—Block diagram of the Lower Cascade Valley and the Cascade Plateau as seen from the Coast.

4,000 ft., the seaward side of which is drained by the Hope River. The country between the Jackson River and the coast is of a similar nature, and, like the Hope-Blue River Range, consists of gneiss and hornfels invaded by granite-pegmatite (Turner, 1930, p. 174).

Possibly the most striking topographic feature is the Cascade Plateau which borders the Cascade Valley on its northern side for a distance of ten miles in from the sea coast, and extends westward for several miles to Carmichael Creek. This feature will be described and discussed fully in a later section.

THE CONGLOMERATE SERIES.

In a previous paper (Turner, 1930) an account has been given of the metamorphic and ultrabasic rocks of the Lower Cascade Valley. These constitute a basement upon which lies unconformably a great series of bedded clastic rocks—mainly coarse, well-cemented conglomerates—derived from the erosion of the underlying formations. These younger rocks are here grouped together as the Conglomerate Series, the origin of which is closely connected with the early stages in the physiographic development of the Cascade Valley.

Rocks of this type, sometimes containing boulders as much as four feet in diameter, are exposed abundantly along the old track, between the bridge across the gorge of Martyr Creek and the ford where it crosses the same stream, about four miles below. The constituent boulders are imperfectly rounded and are set in a hard cemented matrix of fine blue clay (Pl. 81, Fig. 1). The majority consist of fairly fresh peridotite derived from the rocks of the Olivine Range, though masses of gneiss, schist and hornfels also are present. In this locality the gneissic basement is not far beneath, and outcrops from under the mantle of drift in the gorge of Martyr Creek and at intervals along the track. McFarlane, who, in 1877, first explored the Cascade Valley, took advantage of the creek being unusually low to follow down the Martyr Gorge. He notes (1877, p. 30) that "the river having cut clear through to a depth of 150 feet in places, a fine section of the formation is presented, which consists of a heavy conglomerate showing very complete stratification, having a very slight dip to the north-west."

Cemented conglomerate was also observed along the southern slopes of Red Spur, where it falls away steeply into the valley of Martyr Creek (Pl. 81, Fig. 2). It is exposed, almost from the level of the creek to a height of over 1200 ft. above sea-level, in the bed and walls of a narrow gorge leading down from Red Spur. Although here it directly overlies peridotite, the component boulders of the conglomerate are mainly schist—probably derived from the tract of schist country in which the Martyr rises. This fact and the highly indurated state of the rock preclude any possibility of its being simply a hillside talus.

The rocks of the Conglomerate Series attain their most extensive development on the north-eastern side of the lower part of the Cascade Valley, where they underlie the whole of the Cascade Plateau, an area of about 20 sq. miles. The surface of the Plateau is itself

largely covered with a mantle of glacial moraines, the origin of which will be outlined later in this paper. A fine section is exposed in the gorge of Teer Creek, which is the only large stream to cross the plateau. It rises in the ranges to the south-east and cuts north-west across the plateau through a profound gorge about 1,000 ft. in depth. This was crossed at two points, respectively three miles and one mile above the mouth.

At the first of these, conglomerate outcrops in perpendicular bluffs at intervals between the stream bed (possibly 200 ft. above sea-level) and a height of about 1,200 ft. or more. The boulders are large and consist mainly of gneiss, hornfels and schist, to the almost complete exclusion of peridotite.

At the second point, one mile above the mouth of the creek, hard blue mudstone is exposed in the stream bed and is overlain upstream by conglomerate, consisting of subangular but partially rounded boulders set in the usual matrix of hard blue clay. Here again peridotite is rare. There is a regular dip upstream(i.e. south-east) at about 5°. On the west side of the creek, at a considerable height above the bed, steep bluffs are cut in massive mudstones about 100 ft. thick, through which run occasional thin bands containing subangular boulders. These pass up into conglomerate, which appears to continue to a height of about 1,000 ft. or 1,100 ft. above sea-level. Immediately west of this, in the bed of the tributary marked A (Text-figure 3), similar conglomerate is again exposed not more than 200 ft. below the general plateau level, i.e. between 900 ft. and 1,000 ft. above sea-level.

The above observations indicate beyond doubt that the unconsolidated morainic material which covers most of the plateau is actually a relatively thin cover, beneath which lie at least 1,000 ft. of rocks belonging to the Conglomerate Series. Observation of conglomerates in the gorge of Laschelles Creek, and reports regarding exposures in the sea cliffs along the northern margin of the plateau lend support to this conclusion.

Cox (1877, pp. 94, 95) has described strongly folded Tertiary sedimentary rocks, lithologically very different from the Conglomerate Series, from the vicinity of the old settlement at Jackson's Bay, about five miles east of the edge of the Cascade Plateau. It may safely be assumed that the contorted state of these strata is due to the great earth movements of the Pliocene which Cotton has termed the Kaikoura deformation. It follows, then, that the almost undisturbed strata of the Conglomerate Series were most probably laid down subsequently to this movement, and their age cannot in that case be earlier than late Pliocene.

On the other hand, the well cemented nature of the conglomerates and mudstones, their regular stratification, and the slight inclination of the strata (north-west in the gorge of Martyr Creek and south-east in Teer Creek) all point to a pre-Pleistocene age. Morgan (1928) and Marwick (1928) both regard the Pleistocene of New Zealand as a period of extensive glaciation comparable and contemporaneous with the European Pleistocene, and uphold the principle that, in the rocks of the South Island, the Pleistocene-Pliocene boundary should be

FIG. 1.

FIG. 2.

FIG. 1.—Conglomerate, ¼ ml. west of Martyr Bridge, Cascade Valley.
[*G. J. Williams photo*

FIG. 2.—Red Spur and the valley of Martyr Creek, seen from the crest of Martyr Spur. The light coloured area, bare of vegetation, is peridotite, while the forested area to the right is underlain by schist.
[*J. S. Thomson photo.*

FIG. 3.—The Cascade Valley and the Olivine Range, looking south from the Cascade Plateau (1900 ft.). On the right, in the middle distance, is the mouth of the Cascade Gorge, and on the left, the valley of Martyr Creek.
[*J. A. Bartrum photo.*

FIG. 4.—The lower portion of the Cascade Valley, seen from the end of Martyr Spur (500 ft.), looking seawards. The Cascade Plateau forms the sky-line on the right and in the middle of the photograph, while on the left are seen the lower spurs of the Hope-Blue River Range.

[*G. J. Williams photo.*

FIG. 5.—Mt. Richards and the gorge of Woodhen Creek, seen from the peridotite-schist junction on the crest of Martyr Spur (4,000 ft.). Note the bare peridotite in contrast with the bush-covered schist on the left. The snow-covered peaks beyond Mt. Richards are the summit of the Olivine Range.

[*G. J. Williams photo.*

FIG. 6.

FIG. 7.

FIG. 6.—The surface of the Cascade Plateau looking south to Twin Blocks Trig. Nearly all the boulders are peridotite.

[*J. A. Bartrum photo.*

FIG. 7.—Glacier-borne blocks of schist on the surface of the Cascade Plateau, near the source of Duncan Creek.

[*G. J. Williams photo.*

Fig. 8.—Eastern boundary of the Cascade Plateau near the head of Teer Creek, looking northward. On the right is the spur leading up to Colin Hill, while the gorge of Teer Creek cuts across the middle of the photograph from right to left.

[*J. A. Bartrum photo.*

Fig. 9.—The eastern boundary of the Cascade Plateau, with Colin Hill rising beyond to form the sky-line. At this point the upper portion of Teer Creek separates the bare moraines of the Plateau, from the bush-covered hornfels country, of which Colin Hill is the highest point.

[*J. A. Bartrum photo.*

FIG. 10.—Regular marginal moraine, forming a sharp ridge 1½ mls. long, ¾ ml. north-west of Twin Blocks Trig., summit of Cascade Plateau. Note the meandering course of the stream. Photograph taken looking north-west [*J. A. Bartrum photo.*

FIG. 11.—Regular moraines on the north-eastern side of the valley shown in Fig. 10, summit of Cascade Plateau. The almost horizontal line AB is the crest of the ridge marked X in Text-Fig. 3. Beyond it lies another inter-morainic valley, the drainage from which reaches the main valley through an incipient break in the ridge AB, just to the left of A. Note the difference between the height of AB and that of the ridge CD beyond.

[*J. A. Bartrum photo.*

FIG. 12.—Surface of moraine at Twin Blocks Trig. Station, summit of Cascade Plateau. The two large blocks are hornfels, the smaller boulders in the foreground being peridotite.
[J. A. Bartrum photo

FIG. 13.—Junction of streams B and C (Text-Fig. 3), summit of Cascade Plateau, looking north-east. The line X Y Z is the crest of a regular moraine, beyond which lies the deep gorge of Teer Creek. The streams in the foreground reach the latter through the gap Y. The even surface of the Plateau east of the gorge constitutes the sky-line.
[J. A. Bartrum photo.

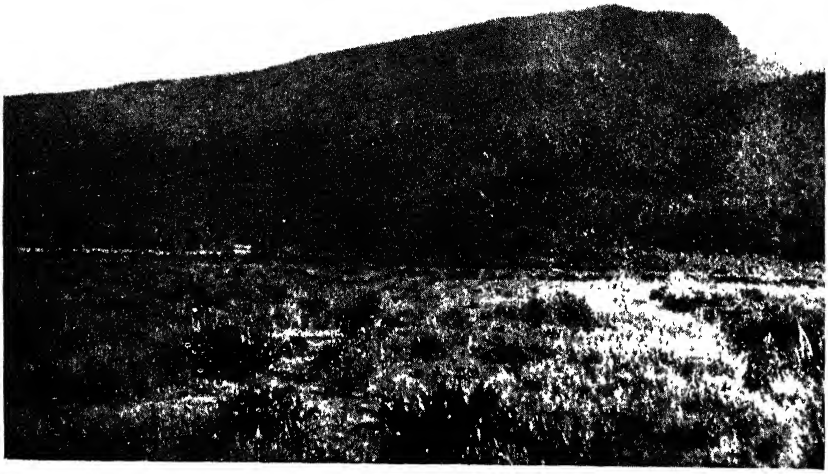


FIG. 14.—Southern end of the Cascade Plateau, as seen looking north from the Cascade Hut, Cascade Valley. On the right is the mouth of Laschelles Creek.

[*J. A. Bartrum photo.*

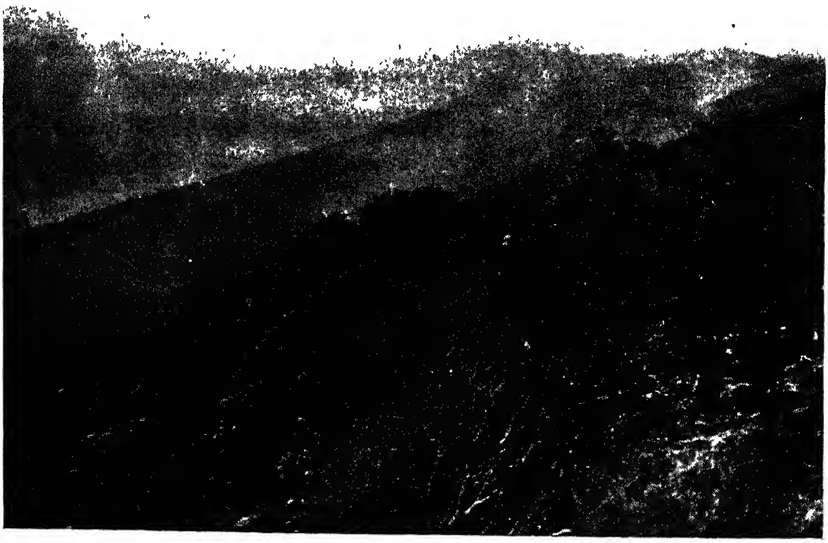


FIG. 15.—Looking north-west into the valley of the Cascade River, from the margin of the Cascade Plateau, west of Twin Blocks Trig. Station. The floor of the valley is hidden in mist, but commencing from the point A, the edge of the lateral moraine which constitutes the terrace at 1,350 ft. above sea-level, is clearly visible, merging gradually into the surface of the plateau in the distance.

[*J. A. Bartrum photo.*

drawn at the base of the earliest deposits of glacial origin. There is no reason to suppose that the Conglomerate Series of the present area represents outwash from Early Pleistocene glaciers. On the contrary, as will be shown later, two series of moraines are definitely known to post-date the deposition and uplift of these rocks.

The Conglomerate Series is therefore regarded as being of late Pliocene age.

From the foregoing description it will be seen that the rocks of this series are limited to areas bordering the Cascade and Martyr Valley, where they occur between sea-level and a height of about 1,200 ft., and are entirely absent from the higher slopes of the adjacent ranges. It follows, therefore, either that the conglomerates originally had a wider distribution, and owe their present limited extent to preservation from erosion in down-faulted areas, or else that they were deposited in a late Pliocene valley, the site of which is still occupied by the Lower Cascade and Martyr Rivers. The field evidence strongly supports the latter view. The writer, therefore, suggests that, towards the close of the Pliocene, a wide triangular depression, probably the result of erosion along lines determined by faulting in the Kaikoura Orogeny, extended across the area which to-day is occupied by the Cascade Plateau and the lower portion of the Cascade Valley. This depression narrowed inland, and continued southward some distance beyond the present great bend in the Cascade River, along the line of what is now the valley of Martyr Creek. As a result of long-continued slow sinking of the land, alluvial gravels, and to a less extent finer sediments, together with pluvial and talus debris, accumulated continuously at the foot of the ranges.

In this way a thickness of over 1,000 ft. of strata was built up. When eventually this phase of slow subsidence and accompanying deposition of gravels came to a close, the land surface must have consisted of dissected mountain-ranges bordering a broad infilled depression, the surface of which sloped gently seaward to sea-level at the coast. The present elevation of the remnants of this ancient surface indicates that at this time the land stood considerably lower (possibly 1,000 ft.) than to-day.

Physiographical Features of the Cascade Plateau.

Between the mouth of the Laschelles Creek and the sea coast the north-eastern wall of the Cascade Valley rises steeply from only a few feet above sea-level to the summit of the Cascade Plateau (Pl. 86, Fig. 14). This is an extensive triangular tableland, about 20 sq. miles in area, which stretches between the Cascade Valley and the eastern side of the Carmichael Creek. At its highest point—Twin Blocks Trig. Station, just above the gorge of Laschelles Creek—it reaches an elevation of 1,900 ft. above sea-level, and thence slopes gently northward to a height of between 800 ft. and 1,100 ft., where it terminates in lofty and precipitous cliffs along the sea coast. This seaward slope is very noticeable as seen from the floor of the Cascade Valley or the lower spurs of the Olivine Range, whence the plateau presents a remarkably even profile in striking contrast with the

ragged sky-line of the adjacent mountain ranges (Pl. 82, Fig. 4). On its eastern border the regular surface of the plateau terminates abruptly against the steep, heavily-bushed slopes of the spurs leading up to Colin Hill and Mt. Alpha (Pl. 83, Fig. 8).

As shown in the previous section, the Cascade Plateau is everywhere underlain by a great thickness of late Pliocene conglomerates. The surface, however, is covered—probably to a depth of over 300 ft. in some places—with unconsolidated moraine. It is littered with large boulders (Pl. 82, Fig. 6) which average about 3 ft. to 4 ft. in diameter, but which frequently are much larger (Pl. 85, Fig. 12) and may even attain 20 ft. or more in average dimension. The majority consist of fresh dunite, wehrlite and harzburgite brought down from the Olivine Range (Turner, 1930, p. 190), but hornfels and schist are also represented (Pl. 82, Fig. 7). As on the peridotite belt itself, the surface is bare of vegetation, except for tussock grasses, rushes, and patches of low scrub, but in the gorge of Teer Creek, where the underlying conglomerates are exposed, the steep slopes are heavily bushed.

Though the plateau appears from below to be regular in the extreme, in reality this is by no means the case; for its surface, upon actual examination, is seen to have a complex and strikingly unusual drainage system, the main details of which are sketched in the accompanying map (Text-Fig. 3). In the north-western corner the major features only are indicated, since the time available was not sufficient to map the whole plateau in detail.

The most important drainage channel is Teer Creek, which rises in the bush-covered hills to the south-east and cuts north by west across the plateau, through the deep gorge described in an earlier section. On either side, the gorge is flanked by a well-defined terrace about 100 ft. below the general level of the plateau, and this appears to represent a bench, where the cemented rocks of the Conglomerate Series outcrop from under the morainic cover.

All the streams west of Teer Creek, including the tributaries of Teer Creek itself, have several striking peculiarities in common. In the first place their valleys and the intervening ridges show perfect parallel disposition along a distance of from five to ten miles. This trend of the topography, though roughly north-west, in reality varies round the arc of a circle, between north, at the southern vertex of the plateau, to almost due west at its north-western corner in the vicinity of Cascade Point. Again, the floors of the valleys are without exception only about 100 ft. or 200 ft. below the general level of the plateau, along the greater part of their extent. The cross-profile is typically V-shaped, though sometimes, as in the case of Creeks B and C, the valley floor may be nearly flat for a width of a quarter of a mile or more (Pl. 85, Fig. 13).

The tributary streamlets are in every case parallel to the major drainage channels; and junction between the two is effected by the tributary turning sharply at right angles to its former course, and cutting through an incision in the intervening ridge. In such cases, it will be noted that the trend of the tributary is usually continued beyond such an outlet, by another stream flowing in the opposite direction (e.g. stream B continuing the trend of stream C).

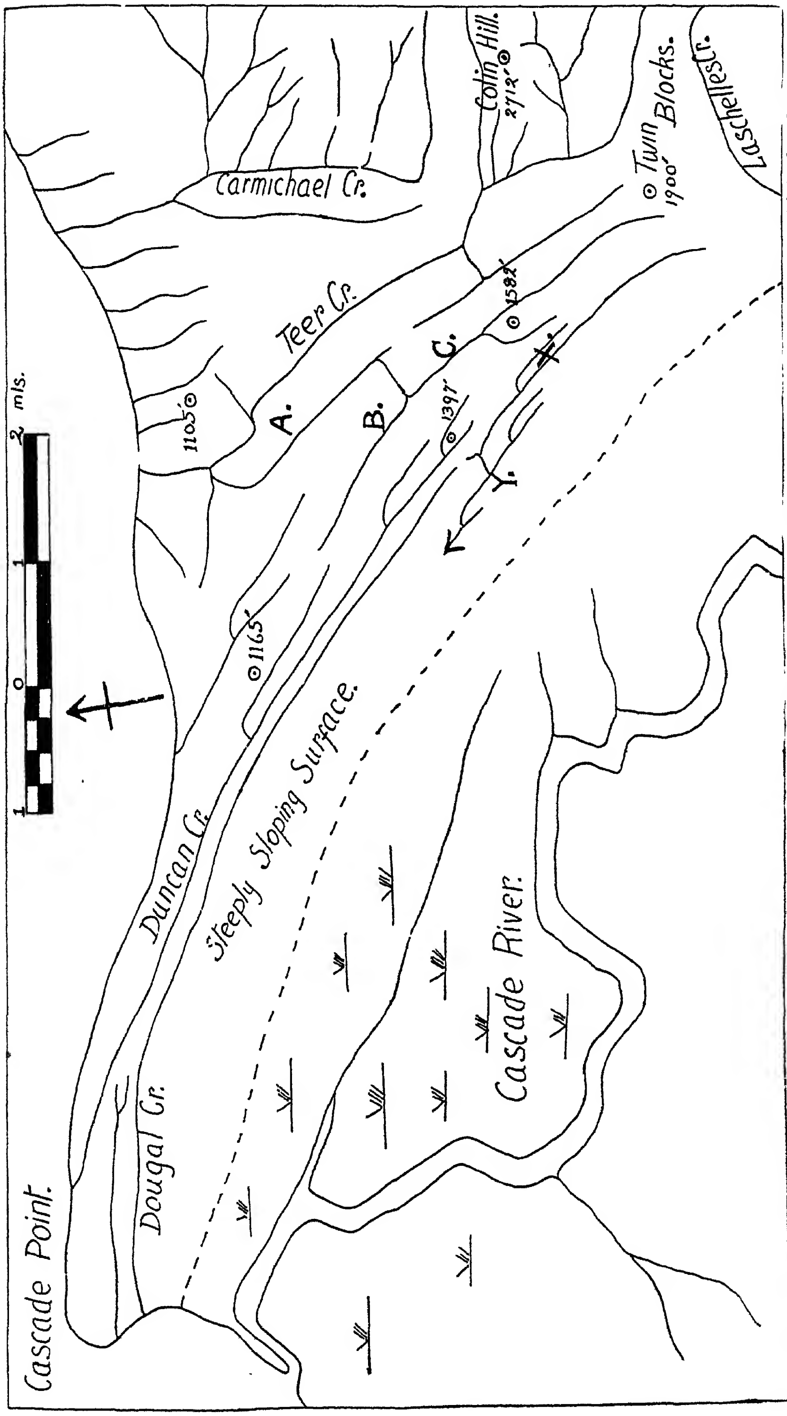


FIG. 3.—Map showing the main drainage features of the Cascade Plateau. (The course of the stream, which is shown terminated by the arrow-head, was not traced below that point).

Origin of the Cascade Plateau.

It might at first sight be suggested that the regular drainage pattern of the surface of the Cascade Plateau is the result of the establishment of consequent streams, flowing down the slope of an uplifted, slightly tilted plain. There are, however, a number of striking and persistent peculiarities, which cannot be explained on the assumption that we are dealing with normal valleys of erosion. These may be outlined briefly as follows:—

(1) The regular sweep of the drainage trend, from north almost to due west, is not in accordance with the due northerly slope of the plateau surface. (The latter has been verified accurately from the surveyed heights of a number of trig. stations at various points on the plateau).

(2) Though the drainage channels have the typically V-shaped cross-profile of the juvenile valley of erosion, the streams themselves are sluggish, and show on a small scale a perfect system of meanders across a narrow belt only four or five yards in width (Pl. 84, Fig. 10). In some cases even there are swamps and small lakelets at the confluence of two or more such streams.

(3) Though the morainic material comprising the intervening ridges consists of boulders of all sizes, yet there is no concentration of the larger masses towards the valley floors, such as must certainly have taken place if steep-walled valleys had been cut in unconsolidated moraine.

(4) The valleys and ridges are unusually closely spaced.

(5) In some cases the summit of a ridge, though regular and obviously not reduced by erosion, may lie from 20 to 50 ft. below the summits of the adjacent ridges (Pl. 84, Fig. 11).

(6) In almost every case the ridges are covered with boulders of peridotite, amongst which masses of schist and gneiss occur to the extent of only about 5 per cent. Nevertheless a single minor ridge (X, Text-Fig. 3), about 400 yds. in length, was found to consist almost entirely of blocks of foliated schist, similar to the distant schists that crown the Olivine Range. In this case, the streams on either side of the ridge X form sharp lines of separation from the adjacent peridotite-covered ridges on either side.

The only hypothesis which will readily explain the above facts is that the plateau is an elevated plain, the surface of which is covered with an immense series of regular, parallel marginal moraines, the spaces between which now act as drainage channels. These moraines have for the most part been but little eroded, since, with the exception of the deeply entrenched Teer Creek, the intervening streams do not rise beyond the confines of the plateau, and hence have little erosive power. Whereas the general uniformity of the plateau surface is due to the fact that the morines have accumulated upon an ancient uplifted plain, the present curious drainage pattern is due to the disposition of the overlying moraines themselves. The writer, therefore, offers the above suggestion as the solution to the problem.

If this solution is accepted, it is easy to picture the material composing the ridge X in Text-Fig. 3 (Pl. 84, Fig. 11), as a small

moraine brought down to the main ice-sheet by some tributary glacier, heading back into the schists of the Olivine Range. The hummocky topography developed round the point Y (Text-Fig. 3), not far from the source of Dougal Creek, also lends support to the idea that the original moraine topography has not been materially altered by post-Glacial erosion.

On its south-western flank the steep slope of the plateau, where it falls away rapidly into the Cascade Valley 1,800 ft. below, is broken by rather narrow, well-defined terraces at heights of 1,350 ft., 750 ft., 450 ft., and 400 ft. above sea-level. Characteristically each terrace is bounded along its inner margin by a streamlet running parallel to the terrace edge about 30 ft. below the terrace level. The uppermost, as seen from the summit of the plateau, is almost horizontal, and bends regularly north-west along the arc of a quarter-circle, until ultimately it intersects the sloping surface of the plateau, and blends into the regular parallel sweep of the surface moraines (Pl. 86, Fig. 15). South of the plateau it is continued as a gently sloping terrace on the flank of the high hills between Laschelles Creek and the Jackson-Martyr Saddle. The above facts, taken in conjunction with the fact that the terraces seem to be made up largely of peridotite boulders, indicate that the terraces are probably of glacial origin, and are to be regarded as the lateral moraines of the ancient Cascade Glacier.

The physiographic evolution of the Cascade Plateau may be summed up briefly as follows:—

At the close of the Pliocene, after the in-filling of the Cascade Depression, elevation of the land, possibly by 800 ft. to 1,000 ft., accompanied by very slight warping, took place. The ancestral Cascade River cut down rapidly through the uplifted rocks of the Conglomerate Series, and became incised in a deep valley, approximately along its present course, flanked on the north-east by an uplifted plain—the Cascade Plateau.

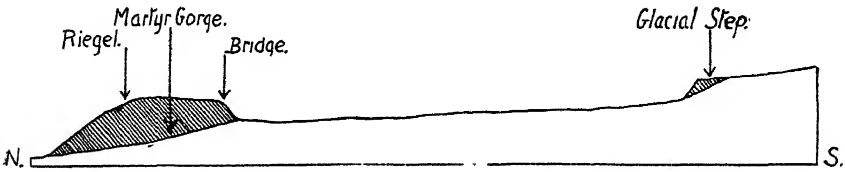
Closely following this came the Pleistocene glaciation. A large glacier flowed down the Cascade Valley, the lower and wider portion of which must have become filled with slow-moving ice. Eventually, as the glacier increased in volume, the ice, which further upstream was hemmed in by lofty mountain walls, appears to have spilled over the valley rim upon the surface of the plateau, across which it pushed out an extensive ice-lobe, which stretched to its eastern and northern boundaries, and so possibly reached the sea coast. During the slow retreat of the ice-front in the later part of the Pleistocene, an immense series of parallel marginal moraines accumulated, marking intermittent periods when the ice neither advanced nor retreated. Further shrinkage of the ice resulted in its withdrawal from the surface of the plateau, though a very large glacier still occupied the valley below. It was at this stage that the lateral moraines, which now form terraces along the north-eastern wall of the Lower Cascade Valley, were deposited by the slowly sinking glacier.

Teer Creek was probably a well-established stream by the time the ice first spread across the plateau, but its gorge has doubtless been deepened considerably since the covering ice sheet withdrew. Otherwise, the only modification of the plateau in Recent times has

been the establishment of the present system of drainage, in which streams now occupy the less elevated areas between adjacent morainic ridges. The latter have been pierced in a number of places to give a more connected stream system—a feature which is well shown in the tributaries on the western side of Teer Creek (Pl. 85, Fig. 13). An incipient outlet of this type, observed at the north-west end of ridge X (Text-Fig. 3), is shown in Pl. 84, Fig. 11.

Glaciation in the Cascade, Martyr and Jackson Valleys.

Corroborative evidence of glaciation is also to be found in the valley of the Cascade River itself. Cirque remnants, often enclosing small tarns, are to be seen at a number of points along the flank of Martyr Spur, high above the gorge of the Cascade, which itself has the U-shaped profile characteristic of glaciated valleys. Again at the north-eastern end of the Hope-Blue River Range, the spurs on either side of the Colin Creek exhibit the steep faces and triangular shape characteristic of ice-shorn spurs. Finally at the base of the steep hill face on the western (inner) side of the great bend in the Cascade River, there is a large patch of bush-covered hummocky moraine with numerous undrained lakelets and ponds interspersed between the hummocks. The accumulation is not more than 100 ft. above sea-level, and was deposited as a terminal moraine just below the entrance of the Cascade Gorge just before the final retreat of the much-diminished glacier as it withdrew from the lower part of the valley. This moraine is therefore considerably younger than those already described from the Cascade Plateau.



Generalised longitudinal section down the valley of Martyr Creek. The shaded portion on the left represents the riegel cut through by the Martyr Gorge, while that on the right shows the incision by which the stream descends the glacial step, which is developed 3½ mls. upstream from the bridge.

During the period of maximum glaciation a large cirque was formed at the head of Martyr Creek, from which a small tributary glacier descended through a hanging valley to the main Cascade Glacier, which it joined near the point where the bridge now spans the Martyr Stream. The lip of this valley, which to-day hangs about 500 ft. to 600 ft. above the floor of the Cascade Valley, is defined by a typical riegel, developed in the gneiss which here outcrops from beneath the less resistant rocks of the Conglomerate Series. At the present time the Martyr cuts through this riegel by means of a very narrow vertical-sided canyon—the Martyr Gorge—which varies between 50 ft. and 150 ft. in depth, and extends for a distance of two miles below the bridge (Text-Figs. 1 and 4). Immediately

above the bridge, the valley of the Martyr opens out into a comparatively wide basin, the floor of which is some 50 ft. below the riegel which shuts it in. This basin has been cut partly in the somewhat easily eroded rocks of the Conglomerate Series.

Further upstream, some 3½ miles south of the bridge, a well developed glacial step is shown in the valley floor, just above the south-eastern boundary of the peridotite belt. A generalised longitudinal section indicating the above features is given in Text-Figure 4.

The U-shaped cross-profile of the original hanging valley of Martyr Creek, surmounting the notch of the outlet gorge, may still be plainly traced, especially when viewed from some such distant elevated point as the summit of the Cascade Plateau (Pl. 81, Fig. 3).

The long straight valley of the Jackson River appears certainly to owe its present form to glacial erosion, though the rectilinear north-easterly course of the original pre-Glacial valley was doubtless, as explained previously (Turner, 1930), determined by the major fault zone which follows along this line, across the Martyr-Jackson Divide, and up the line of the Cascade Gorge. During the period of glaciation an offshoot from the Martyr Glacier continued along this line of structural weakness, across the present divide between the Jackson and the Martyr Valleys, and down the Jackson Valley to the Arawata. This influx of ice accounts for the unusually wide floor of the present Jackson Valley. The point where the ancient glacier cut across the divide is to-day occupied by a wide low saddle only 500 ft. above sea-level, through which the track from the Jackson crosses over into the valley of Martyr Creek. On each side of the saddle almost vertical walls rise to a height of 2,000 ft. or more.

CONCLUSION.

In conclusion the writer wishes to extend his sincere thanks to his companions, Professor J. A. Bartrum, and Messrs. W. E. La Roche, G. J. Williams, J. S. Thompson and G. Simpson.

The expenses incurred on the first expedition (January-February, 1929) were largely met by a Government Research Grant obtained through the New Zealand Institute, while a grant was received from the Otago University to defray part of the cost of the 1930 trip. I wish to express my appreciation of the financial help thus afforded by these two bodies.

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New Species of New Zealand Mollusca from Shallow-water Dredgings.

PART 2.

By A. W. B. Powell, Conchologist and Palaeontologist, Auckland Museum.

[*Issued separately, 29th November, 1930*].

Plates 87–88.

Condylocardiidae.

Genus **Condylocardia** Bernard, 1897.

Type: *C. pauliana* Bernard.

In reviewing the above genus Dall (1903, p. 1437) wrote—"the hinge-teeth only partially emerging from the nepionic state, so that it is difficult to decide what portion of a continuous lamina shall be called cardinal and what part lateral" and "so that when we consider the very amorphous and undeveloped condition of the laminae in *Condylocardia* the relationship and essential similarity of the apparently diverse hinges is tolerably plain."

In the writer's (1930, p. 533) comparison between *Condylocardia* and his new genus *Benthocardiella* the description of the hinge characters of the former were derived from Suter's (1913, p. 910) account of that genus.

The examination of material suggests that Suter's generic description was based on the New Zealand *crassicosta*, for the hinge characters given do not entirely coincide with those of *pauliana* the genotype or *concentrica* the second New Zealand species.

Suter (*l.c.*,) stated that there were four cardinals in the right valve and two in the left, which certainly is the case in *crassicosta* but not in the genotype, as evidenced by Dall's (1903, p. 1437) description in which the right valve is stated to have two and the left valve three cardinals. In *concentrica* the total of six cardinals for the two valves coincides with the number in *crassicosta* but they are differently arranged, there being three in each valve.

However, this apparent diversity is merely the result of more or less rudimentary additions to an original arrangement of two strong cardinals in each valve, caused by the proximal ends of some of the cardinals becoming reflexed forming short hooked accessory cardinals.

In *crassicosta* the two original cardinals in the right valve are thus duplicated to four but the original two remain unchanged in the left valve, giving the formula.*

*The formula used in Dall's adaptation of the Steinmann System. L = left valve, R = right valve, r = resilium, the teeth are represented by units and the corresponding sockets by zeros. For any interlocking masses which cannot be classified as teeth the symbol x is employed.

L. 0.010r010.1 = 2 cardinals + 1 lateral.
R. 1.101r101.0 = 1 lateral + 4 cardinals.

In *concentrica* there is the same total of cardinals but, their arrangement differs slightly. In the right valve the posterior cardinal only is duplicated while in the left valve the anterior cardinal is duplicated giving the formula.

L. 0.010r101.1 = 3 cardinals + 1 lateral.
R. 1.101r010.0 = 1 lateral + 3 cardinals.

Unfortunately the writer has not seen specimens or figures of *C. pauliana* the genotype but Dall (1903, p. 1437) gave the formula as—

L. 1.10r101.0 = 1 lateral + 3 cardinals.
R. 0.01r010.1 = 2 cardinals + 1 lateral.

The essential features of the *Condylocardia* hinge are the reflexing of the original cardinals into accessory hooked cardinals thereby increasing the number to five or six for the two valves and also the presence of a well developed lateral in each valve.

Genus **Benthocardiella** Powell, 1930.

Type: *B. pusilla* Powell.

In the writer's description of the type species the anterior marginal tooth of the left valve was referred to as a lateral. Three additional new species have since been found and study of the hinge characters of these in conjunction with those of the genotype shows that all the teeth are better classed as cardinals and that true laterals or even alternate interlocking margins are foreign to the genus.

The only semblance of marginal interlocking is in the feeble thickening of the valve edges towards the apex of the hinge-line in the left valve. The lack of alternation in these margins, the thickened edges both being in the same valve is possibly an endeavour to preserve balance rather than a tendency towards asymmetry, for the cardinals of the left valve are more massive and weightier than those in the right valve where the thickened margins occur. Apart from this the true hinge-teeth exhibit the usual heterodont alternation.

The essential features of the *Benthocardiella* hinge are the presence of three or four cardinals in the left valve and two in the right and also the absence of laterals or even true alternate interlocking margins.

The typical formula can be expressed as—

L. 010r1010 = 3 cardinals.
R. x01r010x = 2 cardinals.

A fourth shell of the *Benthocardiella* series affords an interesting example of evolution in hinge characters resulting in the formation of an additional cardinal in the left valve. This is brought about by the reflexing of the proximal end of the posterior cardinal in the left valve. This condition is seen developing as a thickened pad in *orbi-*

cula and as a distinct hook in *pusilla*. The formula for this species becomes—

L. 0101r01010 = 4 cardinals.
R. x010rx010x = 2 cardinals.

Benthocardiella obliquata n. sp. (Figs. 4, 5 and 6).

Shell minute, thin, semitransparent, dull-white, moderately convex, equivalve; obliquely elongate-oval, anterior end greatly produced. Surface smooth. Valve margins smooth. Prodissoconch large, bounded by a raised rim and produced anteriorly and posteriorly as projecting rounded knobs. The anterior knob is not so conspicuous as the posterior, being partly immersed in the anterior dorsal margin, which latter is broadly arcuate and very slowly descending. Posterior slope steep, sinuous, truncated, falling away suddenly a short distance behind prodissoconch. Truncated portion slightly concave, subangled on joining the broadly arcuate ventral margin. Hinge typical three cardinals in the left valve and two in the right. The posterior cardinal in the left valve however lacks the hooked proximal end which feature is well developed in *pusilla* and *hamatadens* and is present as a slight thickening in *orbicula*. In the left valve there is first a narrow marginal space for the reception of the posterior thickened margin of the right valve, then a moderately long and narrow simple cardinal, followed by a groove which is obscured by the overhanging nature of the cardinal. This groove is for the reception of a short clasping cardinal in the right valve. After the resilium there is a short clasping cardinal, a socket, another cardinal and finally a narrow marginal space for the reception of the anterior thickened margin of the right valve. In the right valve there is first the thickened margin followed by a socket and a clasping cardinal. After the resilium there is another obscured groove for the reception of the anterior clasping cardinal of the left valve, followed by a long cardinal, then a socket and finally the anterior thickened margin.

Length, 1.06 mm.; height, 0.80 mm. (Holotype).

Length, 0.98 mm.; height, 0.74 mm.; thickness (two valves) 0.45 mm. (Paratype).

Holotype and paratype presented to Auckland Museum.

Habitat, Mangonui Heads in 6-10 fathoms (type). (Mr. W. La Roche. 1922); Tryphena Bay in 6 fathoms, Great Barrier Island (Mr. W. La Roche, 1924).

Benthocardiella orbicula n. sp. (Figs. 1, 2 and 3).

Shell minute, thin, semitransparent, dull-white, inflated, globular. Prodissoconch large, central, projecting, marked off by a rim; anterior and posterior knobs present but not prominent. Surface smooth. Valve margins smooth above but weakly crenulated ventrally by a few very feeble radial folds which are confined to the lower third of the shell. Hinge typical, three cardinals in the left valve and two in the right. In the left valve there is first a narrow marginal space for the reception of the posterior thickened margin of the right valve, then a slender cardinal thickened at the

proximal end, followed by a slight groove for the reception of the posterior cardinal in the right valve. After the resilium there is a short thickened clasping cardinal, followed by a socket, a long cardinal and finally the marginal space for the anterior thickened margin of the right valve. In the right valve there is first the slight thickening of the margin above, followed by a long socket and an equally long cardinal, then resilium, followed by an obscured groove occupied by the short clasping cardinal of the left valve; this is followed by a moderately long flexuous lamellate cardinal, then a socket and finally the slight anterior thickening of the valve edge.

Length, 0.98 mm.; height, 0.98 mm. (Holotype).

Length, 1.06 mm.; height, 1.04 mm.; thickness (two valves) 0.67 mm. (Paratype).

Holotype presented to Auckland Museum.

Habitat, Mangonui Heads in 6-10 fathoms (type). (Mr. W. La Roche, 1922); Awanui or Rangaunu Bay in 12 fathoms. (Mr. W. La Roche, 1922); 38 fathoms off Cuvier Island (Dr. H. J. Finlay); Castlecliff, Upper Pliocene (Dr. H. J. Finlay). The writer is indebted to Dr. H. J. Finlay for the opportunity for examining the Cuvier Island and Castlecliff specimens.

Benthocardiella hamatadens n. sp. (Figs. 7, 8 and 9).

Shell minute, solid, dull-white, semitransparent; moderately convex, equivalve, obliquely-ovate, anterior end produced. Surface smooth, showing faint concentric growth-lines only. Valve margins smooth. Prodissoconch large, erect, bounded by a rim and produced anteriorly and posteriorly into swollen upturned knobs. Anterior and posterior dorsal slopes steep, narrowly rounded anteriorly and broadly rounded posteriorly on reaching the convex ventral margin. Hinge-plate massive, with four cardinals in the left valve and two in the right. In the left valve there is first a narrow marginal space for the accommodation of the posterior thickened margin of the right valve, then a short strong oblique cardinal separated by an almost vertical socket from another short stout cardinal. Both cardinals are more or less connected by being fused above near the margin of the valve, the second one being a duplication caused by the reflexing of the original cardinal as explained in another part of this paper. After the resilium there is space for the reception of an obscure interlocking plate in the right valve, then a long stout cardinal bordering lower edge of hinge-plate, followed by an equally long socket, another long thin lamellate cardinal parallel to the anterior margin and finally the narrow marginal space for the accommodation of the anterior thickened margin of the right valve. In the right valve there is first a thickening of the valve edge towards the apex followed by a short oblique socket, then a large stumpy almost vertical cardinal, followed by a small almost vertical socket. After the resilium there is first an inconspicuous interlocking plate followed by a long narrow socket at lower edge of hinge-plate, followed by an equally long lamellate cardinal, then another long narrow socket and finally a slight thicken-

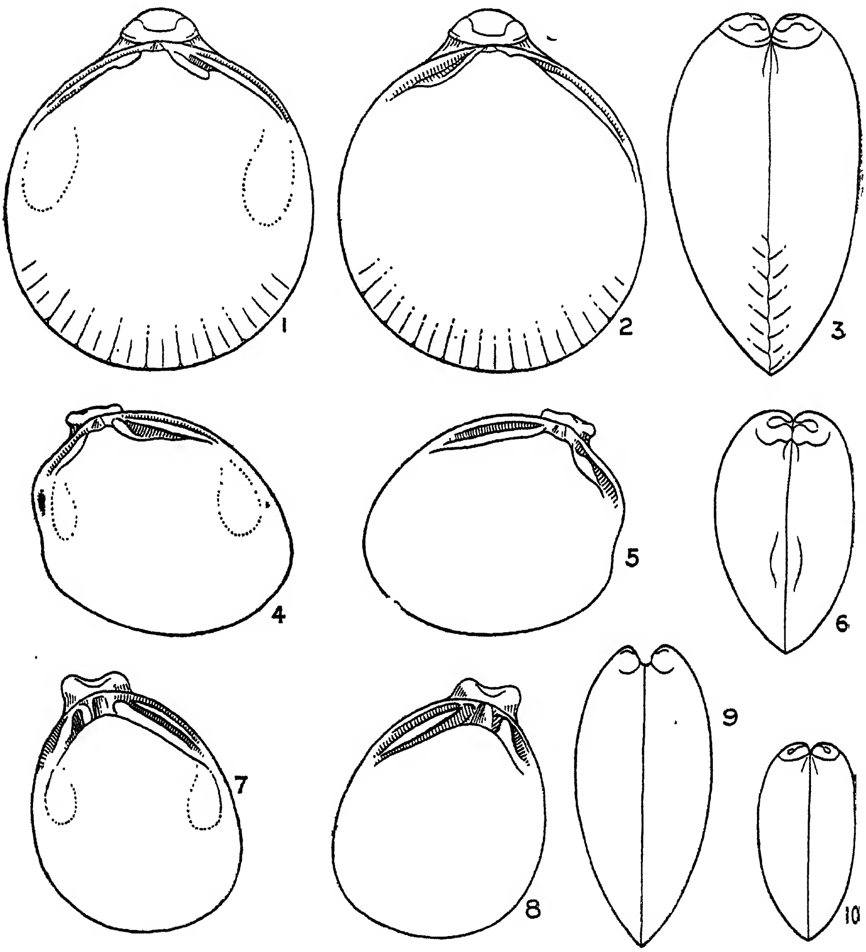
ing of the anterior margin. There are two subequal adductor-scars situated as in the typical species.

Length, 0.87 mm.; height, 0.91 mm. (Holotype).

Length, 0.89 mm.; height, 0.91 mm.; thickness (two valves) 0.56 mm. (Paratype).

Holotype presented to Auckland Museum.

Habitat, Mangonui Heads in 6-10 fathoms. (Mr. W. La Roche, 1922).



Figs. 1, 2 & 3.—*Benthocardiella orbicula* n. sp. (holotype).
Figs. 4, 5 & 6.—*Benthocardiella obliquata* n. sp. (holotype).
Figs. 7, 8 & 9.—*Benthocardiella hamatadens* n. sp. (holotype).
Fig. 10.—*Benthocardiella pusilla* Powell, 1930 (paratype).

Liotiidae.

Genus **Lodderena** Iredale, 1924.
Type: *Liotia minima* Ten.-Woods.

Lodderena formosa n. sp. (Figs. 11 and 12).

Shell very small, almost flat above, tricarinate, widely umbilicated. Whorls 2¾, very rapidly increasing, including protoconch of 1½ smooth, almost flat whorls. Post-nuclear whorls sculptured with fine, close, spiral lirae, about twenty on the upper surface. There are three prominent spiral keels visible from the front, the uppermost bounding the almost flat upper surface, the lowest marking off the base, and the third situated at the periphery midway between the other two. On the upper surface there are two additional spiral ribs intermediate in strength, between the lirae and the keels. On the base, also, there are two of these intermediate spiral ribs, one bordering the umbilicus and the other nearer to the lowest keel. The whole shell is crossed by inconspicuous transverse sculpture which is suppressed for most of its course, being confined to strong crenulations at the sutures and edge of umbilicus and to beading on the keels and spiral ribs. Suture deeply channelled, partly bridged by the crenulations caused by the transverse sculpture. Umbilicus with a crenulated border, deep, vertical-sided, about one-quarter major diameter of base. Aperture heavily variced. Peristome as a smooth continuous inner ring. Colour dull-white (all dead shells).

Major diameter 1.4 mm.; minimum diameter 1 mm.; height 0.75 mm. (holotype).

Holotype presented to Auckland Museum, paratypes in author's collection and collection of Mr. W. La Roche.

Habitat, Mangonui Heads in 6-10 fathoms (type). (Mr. W. La Roche, 1922); 6-10 fathoms, western coast, Great Barrier Island. (Mr. W. La Roche, 1924); Maro Tiri (Chicken Island), in shell-sand at low tide. (Mr. R. A. Falla, December 1923).

This species is closely allied to the genotype which differs mainly in the absence of the three strong keels.

Lodderena nana n. sp. (Figs. 13 and 14).

Shell minute, spire very little raised, tricarinate and widely umbilicated. Whorls 2¾ rapidly increasing, including protoconch of 1½ smooth slightly convex whorls. Post-nuclear whorls with three prominent spiral keels visible from the front and situated as in the preceding species. These keels are very prominent over most of the body-whorl but gradually become obsolete towards the outer lip. The whole shell is crossed by transverse sculpture which, as in the preceding species, is mostly suppressed, being confined to strong crenulations at suture and margin of umbilicus and to beading on the keels, with the exception of the latter part of the body-whorls where axial riblets continue uninterrupted right across the whorl from upper suture to umbilicus. These axials have a tendency to merge, causing fewer and stronger crenulations at the suture, which is deeply channelled as in *formosa.* Umbilicus with a strongly crenulated border, deep, about one-fifth

major diameter of base. Aperture circular, strengthened by a wide lamellate-varix, conspicuous from the front and below but not from above. Peristome continuous with a smooth inner rim. Colour dull-white (all dead shells).

Major diameter 0.72 mm.; minimum diameter 0.58 mm.; height 0.46 mm. (holotype).

Holotype presented to Auckland Museum, paratypes in author's collection and collection of Mr. W. La Roche.

Habitat, Mangonui Heads in 6-10 fathoms. (Dredged by Mr. W. La Roche, 1922).

This species differs from *formosa* in its smaller adult size, absence of the fine spiral lirae and in the presence of stronger radials, not suppressed over the latter part of body-whorl.

ORBITESTELLIDAE.

Genus **Orbitestella** Iredale, 1917.

Type: *Cyclostrema bastowi* Gatliff.

Orbitestella toreuma n. sp. (Figs. 16 and 17).

Shell minute, opaque, solid, discoidal, widely umbilicate. Whorls 3 biangled by two prominent spiral keels. Protoconch exceedingly small, of one smooth slightly keeled whorl. Periphery high, formed by upper keel. Lower keel of lesser diameter giving roughly, a flattened pentagonal outline to the shell, in vertical cross section. Umbilicus wide, perspective, about one-third major diameter. Spire slightly sunken. The whole shell crossed by numerous strong rounded axial costae, nodulous where they cross the spiral keels, and anastomosing towards the sutures, forming swollen nodulous sutural bands above and below. Axial costae obliquely retractive between the two keels and convexly arcuate on base. Interstices of ribs crowded with inconspicuous exceedingly fine spiral striae. Aperture subquadrate. Peristome discontinuous thin, overhanging above.. Colour pale-buff.

Major diameter 0.74 mm.; minimum diameter 0.64 mm.; height 0.27 mm. (holotype).

Habitat, Awanui or Rangaunu Bay, in 12 fathoms (Mr. W. La Roche, 1922); Mangonui in 6-10 fathoms (type) (Mr. W. La Roche, 1922).

This makes the second species of the genus to be described from New Zealand seas.

RISSOIDAE.

Genus **Scrobs** Watson, 1886.

Type. *Scrobs jacksoni* (Brazier) (=*badia* Watson).

Subgenus **Nannoscrobs** Finlay (1926), 1927.

Type. *Amphithalamus hedleyi* Suter.

Scrobs (Nannoscrobs) rugulosa n. sp. (Fig. 19).

Shell minute, solid, broadly-ovate. Whorls 3½ including low dome-shaped protoconch of 1½ convex whorls, minutely stippled

with very numerous exceedingly fine granules arranged in closely spaced linear series. Post-nuclear whorls sculptured with fine inconspicuous anastomosing spiral wrinkle-striae, slightly more prominent over base. Suture impressed, submargined by a moderately wide flat band bordered below by a faint ridge. Spire less than height of aperture. Aperture oblique-oval, much thickened and separated from the body-whorl by a broad elongated crescentic depression. Peristome continuous within. Outer lip continuing over depression and joining up body-whorl with a thickened laminated callosity. Colour dull-pink paler towards suture, base and aperture dull-white.

Height 0.98 mm.; diameter 0.69 mm. (holotype).

Holotype presented to Auckland Museum, paratypes in author's collection.

Habitat, Tryphena Bay in 5-6 fathoms, Great Barrier Island. (Dredged A. W. B. P., 1924).

This species is nearest related to *S. ovata* (Powell, 1927), from which it differs by being more broadly ovate with a shorter spire, more broadly submargined at suture and by the absence of basal spiral grooves and the presence of distinct but faint general post-nuclear sculpture of faint anastomosing spiral wrinkles.

Finlay's genus *Nannoscrobs* is here used subgenerically, as the species described above together with *ovata* are certainly related to *hedleyi* the type of the group, as shown by the style of aperture. However, another small New Zealand species, *elongata* Powell (1927) has an aperture more like that of *Scrobs scrobiculata* (Watson, 1886), while *semen* (Odhner, 1924) presents still another type of aperture. None of these groups are very divergent from typical *Scrobs* so far as shell features go, so it would seem necessary to resort to radula characters before discussing generic values.

Genus **Notosetia** Iredale, 1915.

Type: *Barleeia neozelanica* Suter.

Notosetia unicarinata n. sp. (Fig. 18).

Shell minute, solid, roughly ovate, perforate, carinated by a single strong spiral ridge. Spire a little taller than height of aperture. Whorls 4 including a large smooth protoconch of 1½ whorls, flattened on the top and somewhat oblique. Post-nuclear whorls smooth, traversed by a single strong rounded spiral ridge carinating the periphery. This is situated at about the middle on the spire-whorls. Suture impressed. Body-whorl below peripheral keel and base, evenly convex. Aperture subcircular. Peristome discontinuous but connected across parietal wall by a slight callosity. Outer lip simple, slightly thickened but not variced or internally duplicated, slightly angled above by the termination of the peripheral carina. Lower part of inner lip and basal lip evenly rounded, the former separated from the base by a small crescentic cavity. Colour dull-white.

Height 1.19 mm.; diameter 0.59 mm.(holotype).

Holotype presented to Auckland Museum, paratype in author's collection.

Habitat, Tryphena Bay in 5-6 fathoms, Great Barrier Island. (Dredged A. W. B. P., 1924).

This shell is related to *simplex* (Powell, 1927), which was erroneously ascribed to *Lironoba* by prejudice of the spiral keel. Both these shells are better placed in *Notosetia* on account of the simple apertures, not variced or internally duplicated. The species *simplex* differs from *unicarinata* in being more elongated and in the absence of an umbilical cavity.

Genus **Rissopsis** Garrett, 1873.

Type: **R. typica** Garrett.

Rissopsis expansa n. sp. (Figs. 20 and 21).

Shell minute, thin, semitransparent. Spire tall, almost twice height of aperture. Apex bluntly rounded. Whorls five, including visible portion of heterostrophe protoconch which is not marked off from post-nuclear whorls. The initial whorl of the protoconch is immersed by the volution of the succeeding whorl. Outlines of spire-whorls slightly convex. Body-whorl and base evenly rounded. Surface smooth and glossy. Aperture expanded, oblique, rhomboidal, protractive below. Peristome discontinuous, slightly thickened but not variced. Outer lip convexly arcuate, protractive and projecting at a broad angle from the body-whorl, sub-angled above and broadly rounded below. Inner lip as a connecting callus across parietal whorl, resolving below into a slightly sinuous, rounded and thickened columella, free from the base and merged into the rounded basal lip. Suture impressed, strongly false-margined below by the effect of the coiling and semitransparency of the shell. Colour pale-buff.

Height 1.45 mm.; diameter 0.7 mm. (holotype).

Holotype in author's collection, paratypes in collection of Mr. W. La Roche.

Habitat, Mangonui Heads in 6-10 fathoms. (Dredged by Mr. W. La Roche, 1922).

The genotype of *Rissopsis* is from "Viti and Samoa Isles" and is described as being a delicately transparent shell of 10 mm. in length, having a thin sinuous and expanded peristome.

Expansa is provisionally located in *Rissopsis* for want of a better location.

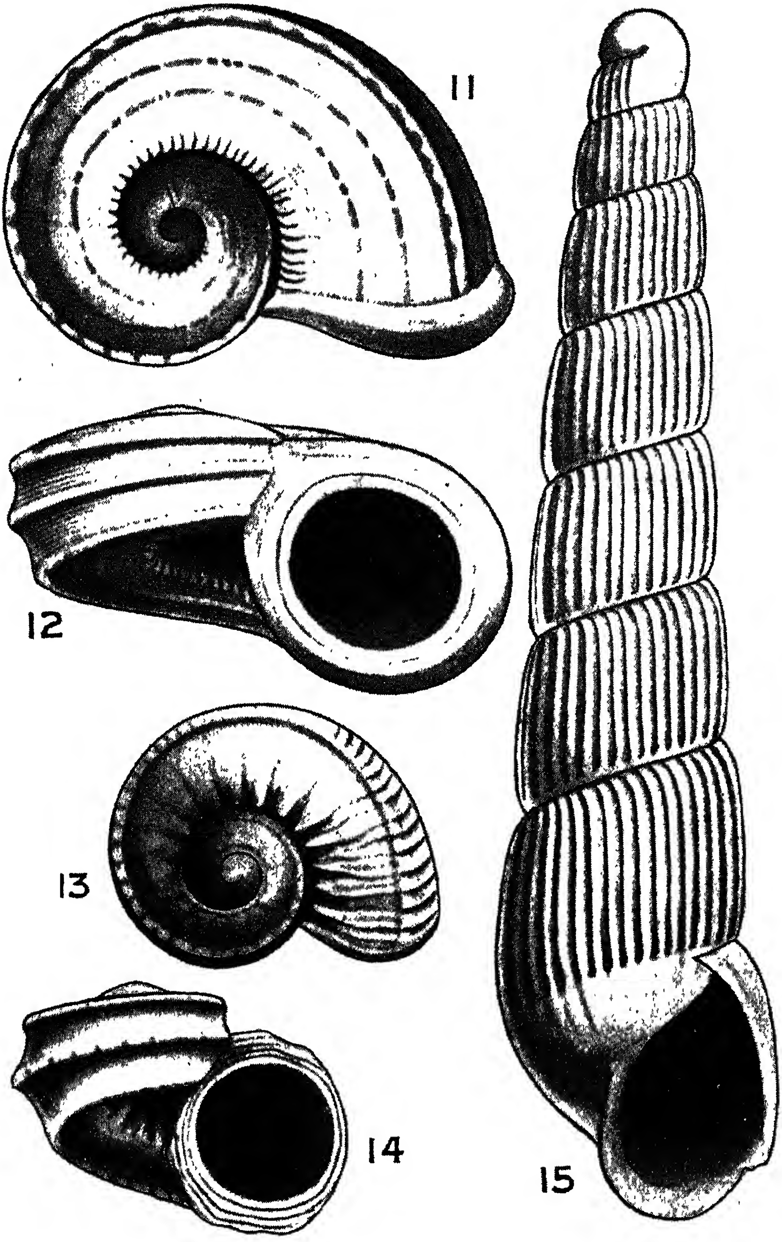
Finlay (this volume, p. 58) has already introduced *Rissopsis* into the New Zealand fauna for the reception of two Tertiary species.

PYRAMIDELLIDAE.

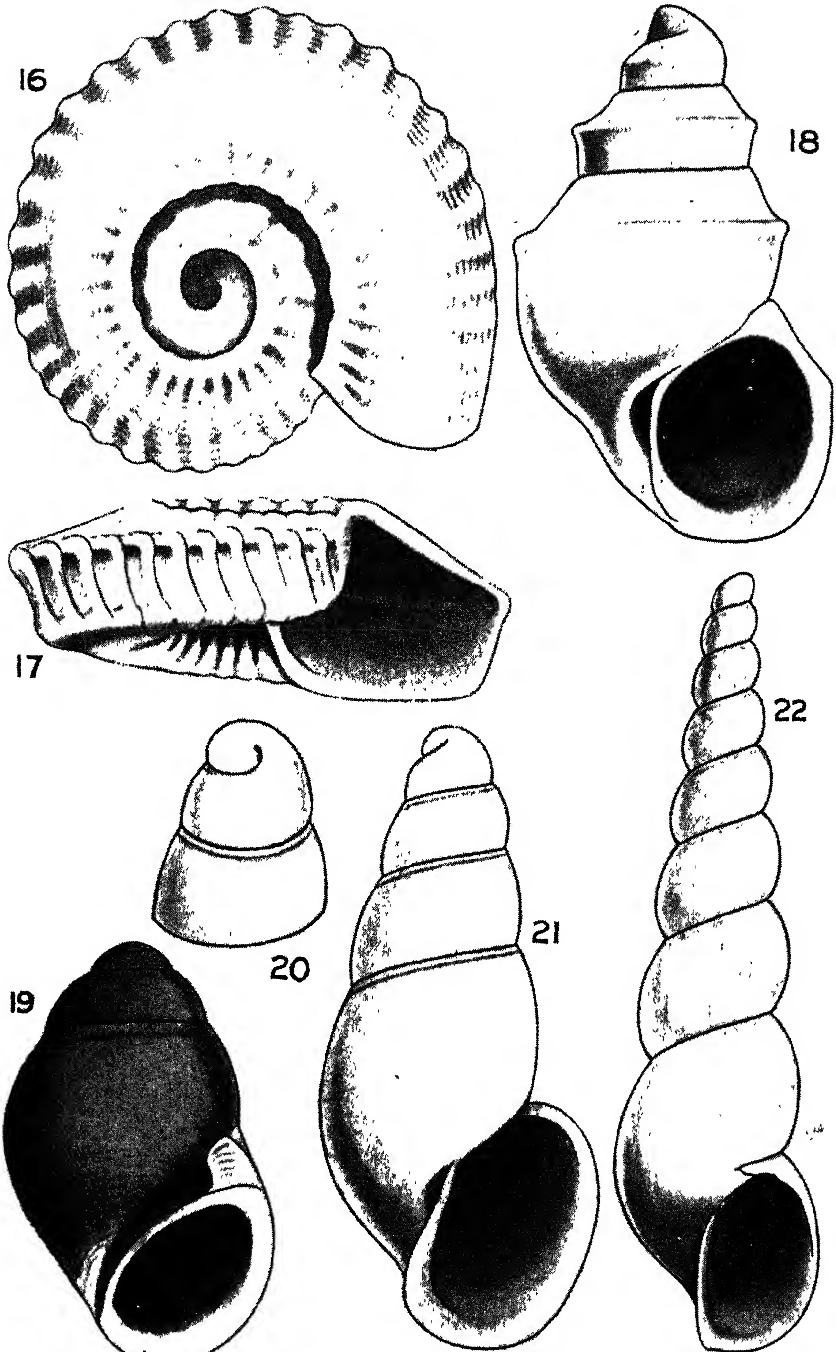
Genus **Eulimella** Jeffreys, 1847.

Eulimella larochei n. sp. (Fig. 22).

Shell small, tapering, many-whorled, thin and semitransparent. Whorls 9 including small smooth globose heterostrophe protoconch, with the initial whorl partly immersed by the next volution. The protoconch is not clearly marked off from the post-nuclear whorls.



Figs. 11 & 12.—*Lodderena formosa* n. sp. (holotype).
Figs. 13 & 14.—*Lodderena nana* n. sp. (holotype).
Fig. 15.—*Turbonilla* (*Chemnitzia*) *aotcana* n. sp. (holctype).



Figs. 16 & 17.—*Orbitestella toreuma* n. sp. (holotype).
Fig. 18.—*Notosetia unicarinata* n. sp. (holotype).
Fig. 19.—*Scrobs* (*Nannoscrobs*) *rugulosa* n. sp. (holotype).
Figs. 20 & 21.—*Rissopsis expansa* n. sp. (holotype).
Fig. 22.—*Eulimella larochei* n. sp. (holotype).

Spire tall, over three times height of aperture. Outline of spire-whorls, body-whorl and base strongly and evenly convex. Suture impressed, distinct, very narrowly submargined. Colour transparent-whitish. Surface smooth and glossy, showing faint protractively-arcuate growth lines. Aperture vertical, subovate, sides almost parallel. Outer and basal lips simple, sharp, protractive. Columella slightly thickened, straight and vertical, merged above into a thin parietal callus.

Height 2.17 mm.; diameter 0.54 mm. (holotype).

Holotype presented to Auckland Museum, paratypes in author's collection.

Habitat, Mangonui Heads in 6-10 fathoms (type) (Mr. W. La Roche, 1922); Tryphena Bay in 5-6 fathoms, Great Barrier Island (A. W. B. P., 1924).; Awanui or Rangaunu Bay in 12 fathoms (Mr. W. La Roche, 1922).

This shell differs from the other New Zealand species in its strongly convex whorls. Judging from figures *Eulimella micra* Petterd and *E. coacta* of May not Watson, both Tasmanian species, have similar strongly convex whorls and are probably related. Also the South African *E. fulgens* Thiele (1925) from off Agulhas Bank in 126 metres is a similarly shaped shell.

Genus **Turbonilla** Risso, 1826.

Type: *Turbonilla typica* Dall and Bartsch (=*T. plicata* Risso, 1826).

Subgenus **Chemnitzia** D'Orbigny, 1839.

Type: *Melania campanellae* Philippi.

Turbonilla (Chemnitzia) aoteana n. sp. (Fig. 15).

Shell small, subulate, opaque, white and shining. Whorls 8½, regularly increasing, including heterostrophe protoconch of 1½ globose whorls with a lateral nucleus. Outline of spire almost flat, whorls only slightly convex. Suture impressed. Post-nuclear sculpture consisting of numerous closely spaced rounded flexuous axial riblets with subequal interspaces. These are lightly chanelled, finishing abruptly just above lower suture on spire and body-whorls, and not extending over the base. The axial ribs are slightly concavely arcuate above but almost straight below, and number about 40 on the body-whorl. Suture impressed. Base rounded, smooth with the exception of a few subobsolete corrugations proceeding from the axial ribs. Aperture subvertical, elongately oval, angled above and narrowly rounded below. Peristome discontinuous, thin and sharp. Columella obliquely-arcuate, merged above into a thin parietal callosity. Colour dull-white.

Height 2.8 mm.; diameter 0.7 mm. (holotype).

Holotype presented to Auckland Museum, by Mr. W. La Roche.

Habitat, western coast, Great Barrier Island in 6-10 fathoms. (Mr. W. La Roche, 1924).

The almost flat outline of the whorls and closely spaced axials make this species quite distinctive.

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New Tertiary Mollusca from New Zealand.

No. 1.

BY C. R. LAWS, M.Sc., Teachers' Training College, Dunedin.

[*Read before the Otago Institute, 12th August, 1930; received by Editor, 15th August, 1930; issued separately, 25th November, 1930*].

PLATES 88-91.

WITH the exception of two shells—*Cardium strangi* n. sp. and *Verconella finlayi* n. sp.—the Mollusca described in this paper have been recently collected by the writer. His sincere thanks are due to Dr. H. J. Finlay and to Dr. J. Marwick for assistance in identification, and also to Dr. W. N. Benson for permission to describe the very fine new species of *Cardium* from Chatton.

Genus **Glycymeris** Da Costa, 1778.
Type *Arca glycymeris* Linné

Glycymeris marshalli n. sp. (Figs. 13, 14).

Shell large, light of build for its size, inflated, beaks low. Outline very oblique; the line joining the apices of the chevrons (four in number) on the ligamental area correspondingly oblique. Shoulders high, little sloping. Anterior winged dorsally and descending rapidly at first, but later retreating more postero-ventrally. A fairly strong ridge running from the umbo intersects the posterior margin just below its middle forming a rounded angle. Above this the descending dorsal half of posterior margin runs postero-ventrally, thereafter inclining antero-ventrally. Sculpture of numerous flat radial ribs separated by almost linear grooves, not on the posterior wing, where, however, a hand lens shows fine, closely-spaced radial striations, found also on the anterior dorsal surface, but not seen elsewhere no doubt as a result of the partially decorticated state of the shell. Teeth numerous and light, 6 to 7 fully developed on each side of ligamental area.

Height, 74 mm.; length, 69 mm.; inflation 20 mm.

Locality—Shell Gully, Chatton, near Gore, Southland (Ototaran).

Holotype and two broken paratypes in writer's collection.

The build of shell, hinge characters and sculpture show that this species has affinities with shells of the "*Axinea*" group, as used by Marwick (*Trans. N.Z. Inst.*, vol. 54, p. 64; 1923).

Genus **Dosinia** Scopoli, 1777.
Type *D. africana* Hanley.
Subgenus **Raina** Marwick, 1927.
Type *D. bensoni* Marwick.

Dosinia (Raina) benereparata n. sp. (Figs. 2, 3).

Shell large, moderately inflated, slightly higher than long, drawn down postero-ventrally; beaks situated at about anterior third; dor-

sal margin well arched up. Lunule long, lanceolate, fairly well impressed; escutcheon well marked and moderately deep. Hinge-plate not quite as wide and heavy as in *bensoni*, arched up especially behind posterior cardinal tooth. Dentition closely similar to that of the type of the subgenus but posterior cardinal somewhat more lamellar, anterior lateral higher and narrower and median cardinal perhaps not quite so unevenly divided. Sculpture of unevenly-spaced concentric ridges, crowded together closely towards ventral margin. Pallial sinus moderately deep, sharp and directed towards lower third of anterior adductor. Base of adductor scars just about at middle horizontal line of shell, whereas those of *bensoni* extend well below that line.

Height, 54 mm.; length, 50 mm.; thickness (one valve), 14 mm.

Locality—Shell Gully, Chatton, Southland (Ototaran).

Holotype and a broken paratype in writer's collection.

As the writer found difficulty in referring this and the following species to their subgenera he forwarded them to Dr. J. Marwick for examination. Dr. Marwick places them both in *Raina*, and states concerning the present shell that it is relatively higher than *bensoni*, the pallial sinus is directed much lower than usual in *Raina* and the anterior lateral tooth is high and narrow.

Dosinia (Raina) bartrumi n. sp. (Figs. 5, 7).

A large, heavily-built, inflated and orbicular shell. In dentition (left valve) and sculpture strongly reminiscent of *R. nukumaruensis* Marwick, but left median cardinal is wider and the lunule is not quite so impressed and is relatively longer in Dr. Marwick's species. Escutcheon well developed and deep. Pallial sinus directed towards middle of anterior adductor (thus agreeing more with *nukumaruensis* than with *bensoni*, but not so low as in the previously described species), acute and reaching about half-way across valve. At intervals of about 5 mm. one of the concentric ridges, which over the entire valve are fine and densely packed together, is more prominent than the others, standing out in somewhat more marked relief where there has been slight abrasion of the surface.

Height, 65 mm.; length, 64 mm.; thickness (one valve), 23 mm.

Locality—Kaawa Creek Beds, West Coast, South of Waikato Heads (Waitotaran).

Type (a single left valve) in writer's collection.

Of this shell Dr. Marwick writes, "Inflation greater than in any other *Raina*. Lunule relatively short and more impressed than usual. *R. nukumaruensis* is fairly well inflated and has a slightly more impressed lunule than *bensoni;* but has not so deep an escutcheon, a narrower left median cardinal and a large anterior lateral."

Named in honour of Professor J. A. Bartrum, who first discovered the fossiliferous Kaawa Creek Beds, in recognition of the kindly assistance he has always been ready to give the writer over a number of years.

Genus **Cardium** Linné, 1758.

Type *Cardium costatum* Linné.

Cardium strangi n. sp. (Figs. 6, 9).

Shell large, oblique, drawn out postero-ventrally, inflated; anterior end convex, posterior end flattened; beaks at about anterior third, incurved, flattened in the plane of the hinge, directed forward. Posterior margin parallel with antero-ventral margin, produced and angled below. Ventral margin convex, ascending more in front, strongly and sharply dentate. Sculpture of about 50 broad, regular radial ribs, which tend to be somewhat flattened over most of the shell, but are more or less ridged and nodular towards basal margin; ribs separated by deep, linear grooves. On the posterior flattened area the ribs are ill-formed, the interstices wider and shallower. Growth-lines weakly defined towards ventral margin, but strongly shown undulating across the weaker ribs and grooves of the ventral part of flattened posterior area. As a result of decortication towards the beaks the radials stand out clearly, separated by flat-floored grooves whose width is sub-equal to that of the ribs. The whole are crossed by a system of fine, slightly wavy striae, about 6 to 8 per mm., those in the grooves faintly convex ventrally, those on the ridges convex dorsally. Muscular impressions strongly incised, the posterior one the larger, pedal retractor scar separate, large and elongate dorso-ventrally, hidden by hinge-plate. Hinge with two cardinal teeth, the dorsal one slightly anterior to beak and a little elongated in a direction parallel with the dorsal part of the anterior margin. The lower cardinal much larger, resembling a conical peg protruding from hinge-plate, slightly behind the beaks. Cardinals separated by a channel opening into a deep pit anterior to the lower cardinal. There are two anterior laterals, placed vertically one above the other and separated by a broad, deep pit; upper one low, elongated horizontally; lower one high, conical, pointed. Posterior lateral tooth near remote end of hinge-plate, rising abruptly from its ventral margin and with a broad pit running from above it postero-ventrally to the end of hinge-plate. Nymph broad and strong.

Height, 95 mm.; length, 105 mm.; thickness (one valve), 38 mm.

Locality—Shell Gully, Chatton, near Gore, Southland (Ototaran).

Holotype (a single right valve) in the collection of the University of Otago.

This species has affinities with *C. spatiosum* Hutton, and is allied to an undescribed species from Clifden, Southland, in the collections of Dr. H. J. Finlay and of the University of Otago.

Named in honour of its discoverer, Mr. D. U. Strang, of Invercargill.

Genus **Elachorbis** Iredale, 1915.

Type *Cyclostrema tatei* Angas.

Elachorbis albolapis n. sp. (Figs. 10, 11).

Shell very small, perforate, discoidal, turbinate. Protoconch of about 2½ smooth turns; whorls about 4, ornamented by strong,

sharply-elevated, regular spirals, spaced evenly, especially over the base, but interval between the third and fourth from suture of body whorl greater and almost twice that of others. Interspaces considerably wider than the ridges. Spirals visible on the coils within the wide, perspective umbilicus; about 18 on body whorl, the first two below suture weaker than the others, the ninth stronger, forming a slight angle separating the upper convex part of whorl from the slightly flattened base. Spirals seen through light callus of inner lip and within aperture; 4 on penultimate whorl. Aperture almost circular, sharp, shining within and corrugated outside by the spiral sculpture. There is a shallow infrasutural furrow bounded below by the strengthened third spiral.

Height, about 1.5 mm.; diameter, 3 mm.

Locality—White Rock River shell bed (Awamoan), South Canterbury.

Type in writer's collection (one shell).

This is the second species of *Elachorbis* described from White Rock River, which is the type locality for *E. helicoides* (Hutton). The writer recently collected *E. politus* (Suter) there also. Its strong, regular corrugations at once separate it from the latter species, and this feature combined with the absence of keels readily distinguishes it from Hutton's shell and from *E. duplicarina* Marwick from Chatton. In sculpture it approaches *E. cingulatus* (Bartrum) from the Pliocene beds at Kaawa Creek, and an allied undescribed species in the writer's collection from Hawkes Bay, but in these the whorls are more evenly convex and no spirals ornament the umbilicus.

Genus **Modelia** Gray, 1840.

Type *Turbo granosus* Martyn.

Modelia nukumaruensis n. sp. (Fig. 8).

Shell not large, very thick and solid for its size, imperforate, with strong spiral ornament. Sculpture consists of equally strong, well-spaced spiral lirae, the interstices of about the same width as the spirals, which bear smooth, evenly-spaced granules. The first spiral below the suture is markedly weaker than the others, and is separated from the second spiral by an interval wider than those between the others. The penultimate whorl has nine spirals (twelve in *granosa*). On the base the spiral ornament becomes somewhat sharper, the width of the interspaces increases to about twice that of the ridges, the granular character of which becomes less noticeable (the bases of two juvenile paratypes from Kai Iwi are entirely devoid of granules). Below the periphery of the body whorl several weak cinguli appear in the interstices emerging from beneath the callus of the inner lip, and these enlarge spirally towards the outer lip. Fine, dense growth-lines trend obliquely across the interstices and are visible also on the inter-granular saddles of the lirae (as in *granosa* Martyn). The early sub-nuclear whorls carry a fenestrated ornament due to low, somewhat oblique axials connecting the granules of the spirals. Protoconch (juvenile from Kai Iwi) smooth

and of about two whorls. Earliest whorls only lightly convex, but later ones become progressively more rounded; base convex. Aperture somewhat quadrate, not so oblique as in *granosa* Martyn. Outer lip sharp. Columella concave, oblique, iridescent.

Height, 18 mm.; diameter, 15 mm.; height of spire, 10 mm.

Locality—Pliocene beds of Kai Iwi (Castlecliffian), and Nukumaru (Nukumaruan).

Holotype (Nukumaru) and two juvenile paratypes (Kai Iwi) in writer's collection.

Readily distinguished from *granosa* Martyn by its smaller size, higher spire, less distended and less oblique aperture, and fewer and more regular spirals.

Finlay (*Trans. N.Z. Inst.*, vol. 57, pp. 366-7; 1927) drew attention to the fact that no Tertiary ancestors of *Modelia and Lunella* were up to that time known, stating that this was certainly due to the almost total lack of quite littoral fossil deposits in New Zealand, for the ancestors of such distinct shells must certainly have lived in the same locality. In 1928, however, Professor J. A. Bartrum and the writer collected several specimens of the new species from the mid-Pliocene beds at Nukumaru and at Kai Iwi, while still more recently Powell and Bartrum (*Trans. N.Z. Inst.*, vol. 60, p. 413; Pl. 42, Fig. 63; 1930) describe and figure a shell allied to *granosa* Martyn, which they collected from beds of the Waitemata Series at Oneroa, Waiheke Island, the shallow-water facies of which is shown, as these writers point out (*loc. cit.*, p. 396), by the presence therein of such genera as *Haliotis, Cellana, Bembicium, Lepsiella, Pyrazus, Bankia.*

Genus **Sinum** Roeding, 1798.

Type *Helix haliotoidea* Linné.

Sinum marwicki n. sp. (Figs. 1, 4).

Shell small, greatly depressed; whorls nearly three including a smooth, planorboid protoconch of one and a-half whorls; last whorl enlarging fairly rapidly; apex excentric and nearer front edge; spire flat, about one-fifth height of shell, and dorsal surface convex; body whorl lightly excavated ventrally between inner edge of aperture and outer margin of base, the concavity becoming more marked towards the small, partly hidden umbilicus. The upper surface has slightly undulating, somewhat flattened spiral threads, about 35 in number (3 per mm.), separated by grooves slightly wider than the ridges. Towards the periphery the last ten or so lirae suddenly become finer and the width of the interstices less in relation to that of the ridges. These are crossed by well-defined convex growth-lines. No spirals are developed on the base, but the lines of growth are prominent as they sweep convergingly into the umbilical tract. Suture markedly tangential. Aperture large, circular, nearly two-thirds greatest diameter of shell, angled above. Outer lip thin and strongly convex; inner lip covering parietal wall (callus partially broken away in specimen), reflexed and partly hiding umbilicus.

Height, 5 mm.; greatest diameter, 14 mm.; least, 11 mm.

Locality—White Rock River shell bed (Awamoan), South Canterbury.

Holotype (the only specimen) in the writer's collection.

This is the third species of *Sinum* s. str. described from the Tertiary of New Zealand. It is not unlike *S. infirmum* Marwick from the Awamoan beds of Ardgowan and Pukeuri, but is readily separable on account of its less excentric apex and more compressed character, causing a sharper periphery to the body whorl, which also enlarges less rapidly in the new species than it does in *S. infirmum*.*

Genus **Verconella** Iredale, 1914.

Type *Fusus dilatatus* Q. and G.

Verconella finlayi n. sp. (Figs. 12, 15).

Closely allied and probably ancestral to *V. marwicki* Finlay (*Trans. N.Z. Inst.*, vol. 61, p. 67; Pl. 2, Figs. 15 and 16), which it resembles in detail of sculpture and general build of shell, but it differs at sight in its less slender and less graceful outline. Spire relatively shorter than that of *marwicki*, but wider at base, so that it rises less steeply; spire 2½ times height of aperture plus canal, whereas in *marwicki* it is slightly over twice the height of aperture plus canal. Tubercles, especially those on body whorl, placed less than their own width apart, 10 on penultimate and 11 on body whorl. Periphery even lower than in *marwicki*, the suture undulating over the tubercles and on the penultimate whorl almost covering them. Shoulder of body whorl a good deal more excavated than that of the Mt. Harris shell.

The following are measurements taken in comparing shells of the same length, the specimen of *V. marwicki* being a topotype (Mt. Harris):

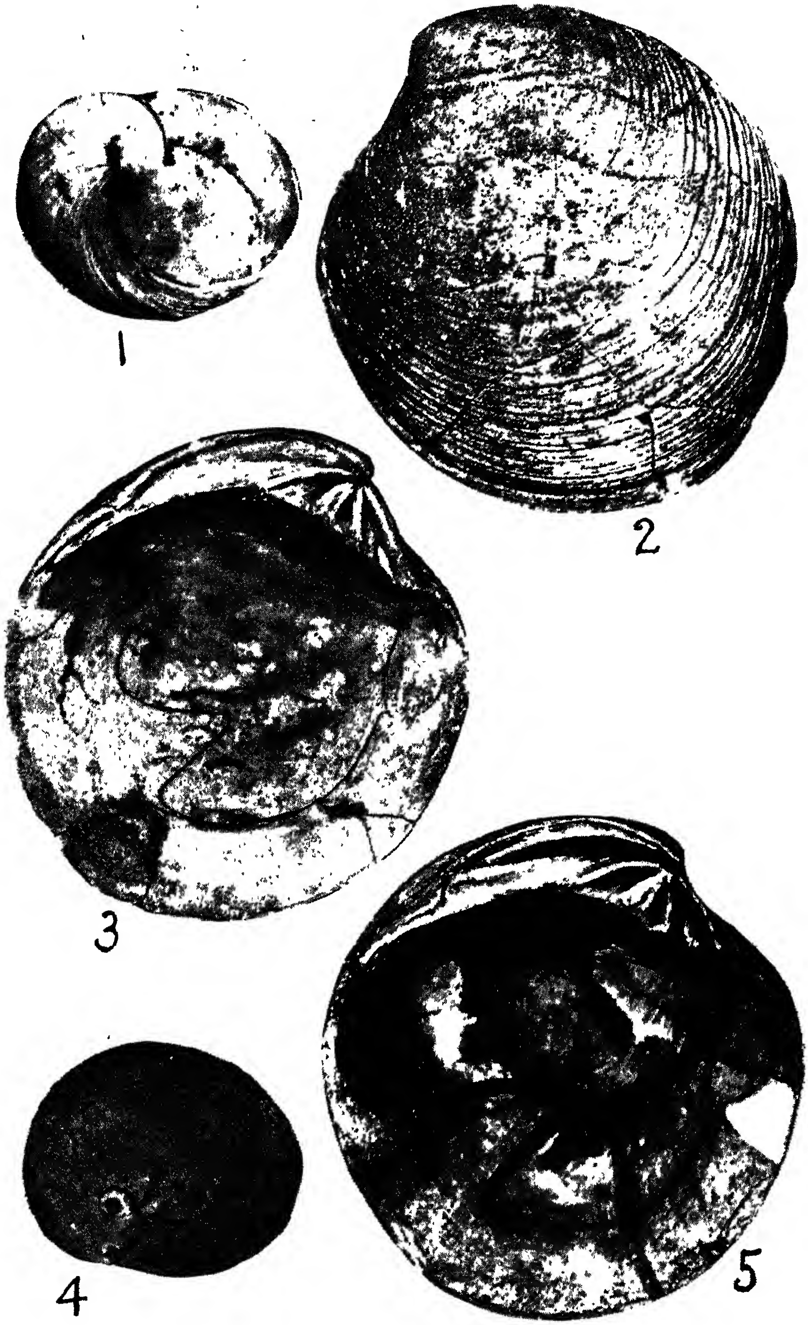
	marwicki	*finlayi*
Length	98 mm.	98 mm.
Height of spire	33 mm.	31 mm.
Width of body whorl	55 mm.	60 mm.
Length of suture of body whorl	95 mm.	109 mm.
Angle of spire	68°	80°

Locality—Blue Cliffs, South Canterbury, sandy clays above limestone (Hutchinsonian). Collected by Dr. P. Marshall.

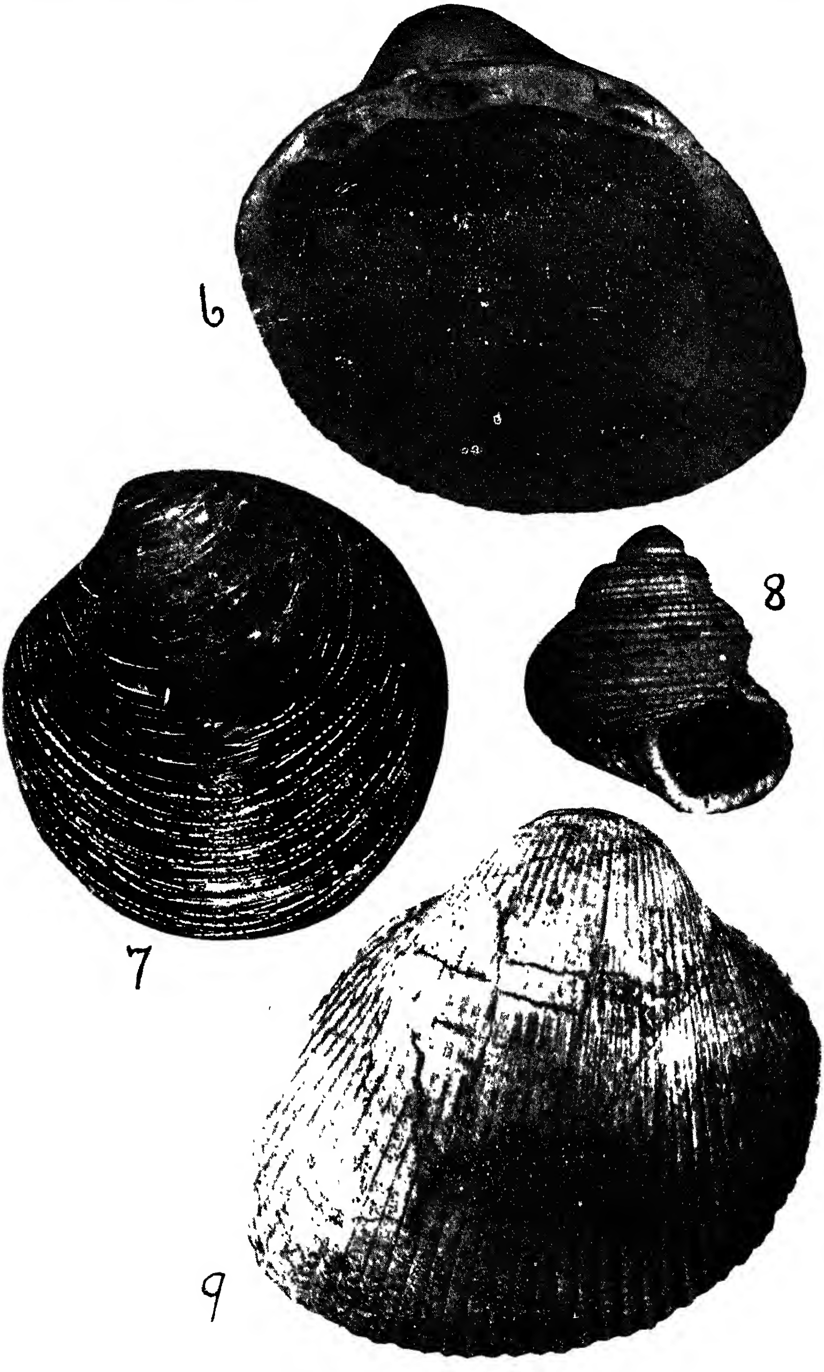
Holotype (unique) in writer's collection.

Separable at sight from *V. marwicki* by the relatively greater width of the last whorl, with its more excavated shoulder, greater angle of spire and lower periphery to whorls.

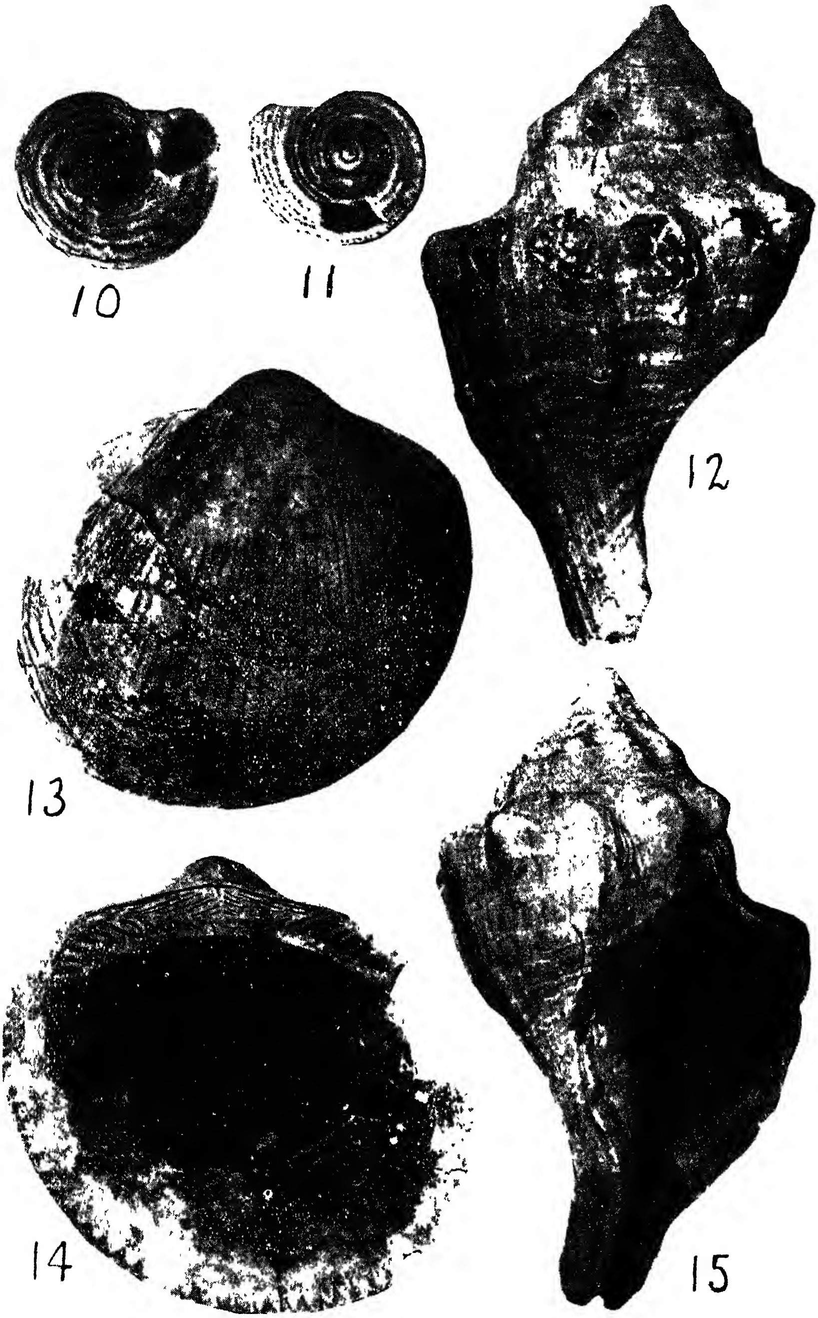
* Since the above was written the writer has collected a perfectly preserved topotype of *S. infirmum* Marwick, its dimensions being slightly less than those given for the holotype.



FIGS. 1, 4.—*Sinum marwicki* n. sp.: holotype, × 3.
FIGS. 2, 3.—*Dosinia* (*Raina*) *benereparata* n. sp.: holotype, × 1.2.
FIG. 5.—*Dosinia* (*Raina*) *bartrumi* n. sp.: holotype, × 1.1.



Figs. 6, 9.—*Cardium strangi* n. sp.: holotype, × 0.8.
Fig. 7.—*Dosinia* (*Raina*) *bartrumi* n. sp.: holotype, × 1.
Fig. 8.—*Modelia nukumaruensis* n. sp.: holotype, × 2.2.



Figs. 10, 11.—*Elachorbis albolapis* n. sp.: holotype, Fig. 10 × 10.
Figs. 12, 15.—*Verconella finlayi* n. sp.: holotype, × 0.9.
Figs. 13, 14.—*Glycymeris marshalli* n. sp.: holotype, × 0.9.

This is another species of the *marwicki-adusta* line, discussed by Finlay (*Trans. N.Z. Inst.*, vol. 61, pp. 67-70). In its very low periphery and almost straight spire whorls the new species resembles a specimen (in the writer's collection) of *V. affixa* Finlay from Clifden, band 6 B. The differences in sculpture, however, between *marwicki* and *affixa*, noted by Finlay (*loc. cit.*, p. 69), exist also between the latter species and that described above.

The writer has pleasure in associating this shell with Dr. H. J. Finlay, who has given him a great deal of assistance and advice in molluscan matters generally.

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List of Lepidoptera of Whangarei.

By Commander S. C. Patterson.

Communicated by G. V. Hudson, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 28th May, 1930; issued separately, 29th November, 1930*].

I wish to place on record my thanks and indebtedness to G. V. Hudson, Esq., F.E.S., F.N.Z. Inst. It was entirely due to his kindly encouragement that I commenced these investigations and to his constant help in every way, more especially in identifying specimens for me, and to his beautiful book, that I have been able to carry them out.

The district worked was Paranui Hill, about 3 miles East of Whangarei Post Office. The house is upon the extreme South corner of a plateau. To the East is a considerable gully clothed in heavy bush (a scenic reserve) having a stream running through the bottom, and reaching to within a few yards of the house. Beyond this gully is a large area of gumfield covered with stunted scrub rising to about 800 feet. Only the extreme edge of this gumfield, adjacent to the gully, has been worked.

To the South-west is also a considerable area of bush, below which is scrub and a few small swamps eventually dropping down to the river about 150 feet below. To the West and North are orchards surrounded and divided by shelter belts of Pinus insignis, Cupressus macrocarpa and native trees and shrubs. Beyond the orchards are pastures with patches of scrub in places. All insects mentioned in this list have been taken within a half-mile radius of the house, except where otherwise stated.

In these notes L means attracted by light.
B means beaten out of bush during the daytime.
S means beaten out of scrub, shelter belts, edge of bush, etc., at dusk.
T means taken from tree trunks.
F means attracted by blossoms chiefly Buddlea of which there is a large bush near the house.

Butterflies.

Danaida plexippus	One seen in orchard, 1923. Two reported in Whangarei district, 1928-29.
Dodonidia helmsi	Two seen in orchard, February, 1926. Several February, 1929. Several February, 1930.
Vanessa gonerilla	Occasionally in orchard.
V. itea	One seen February, 1929.
V. cardui	Several on hilltops at Kara, eight miles West of Whangarei.
Chrysophanes salustius	Rather frequent in November and December, but never numerous.
Lycaena labradus	Abundant from October throughout.

ARCTIADAE.

Nyctemera annulata	Common throughout the entire year.

NOCTUIDAE.

Heliothis armigera	Numerous on F in January and February.
Agrotis ypsilon	Common.
Graphiphora compta	Several, F.
Aletia unipuncta	Not uncommon, L.
Persectania steropastis	Occasionally, L.
P. composita	Rather common, L.
P. atristriga	At times rather numerous, L.
Erana graminosa	Rather numerous throughout the season, L. and T.
Melanchra insignis	Rather common, L.
M. plena	Rather common, L and T.
M. mutans	Rather common, L.
M. ustistriga	Occasionally, L and F.
M. lignana	Rather common, L.
M. ochthistis	Occasionally, L and F.
Bityla defigurata	Occasionally, L.
Ariathisa comma	At times numerous, L.
Hypenodes costistrigalis	Rather numerous during August and September, S. Occasionally, throughout season, L.
H. anticlina	Taken November, B.
Catada lignicolaria	Occasionally, L.
Plusia chalcites	Occasionally, L, numerous, F. Common.
P. oxygramma	Not uncommon, F, February and March.
Dasypodia selanophora	Occasionally, L.
Rhapsa scotosialis	Very numerous.

SPHINGIDAE.

Sphinx convolvuli	One taken in a garden in Whangarei, March. The larva is fairly often found on kumara plants in the district.

GEOMETRIDAE.

Tatosoma lestevata	Taken October, L.
T. tipulata	Not uncommon in December and January in house and T.
T. timora	Occasionally throughout the year, L. Not uncommon.
T. topia	Rather numerous August and September, L. Occasionally in January and February.
Microdes epicryptis	Several August and September. Occasionally November and December, L.
Phrissogonus laticostatus	Rather numerous, L and B and S.

P. testutalus	Occasionally. B.
Chloroclystis semialbata	Rather numerous, L, S.
C. plinthina	Several July, August, September, L.
C. paralodes	Rather numerous July, August, September, L. Occasionally January and February.
Eucymatoge gobiata	Occasionally from August throughout the season, L and B and S.
E. anguligera	Occasionally from September throughout the season, B.
Hydriomena rixata	Rather numerous during November, B.
H. similata	Frequent throughout the year, L, B and S and T.
H. callichlora	Occasonally, L, B and T.
H. deltoidata	Rather numerous February, S.
H. subochraria	Occasionally, L and S.
Asthena pulchraria	Abundant throughout the year, L, B, S.
A. subpurpureata	Abundant July, August, September. Occasionally throughout.
Euchoeca rubropunctaria	Very numerous throughout.
Venusia verriculata	Numerous August and September. Several January and February, L, B.
V. undosata	Taken August, L.
Orthoclydon praefeetata	Occasionally October and December, L, S.
Asaphodes megaspilata	Numerous throughout, L, B and S.
Xanthorhoe rosearia	Odd examples during the winter. Rather numerous August and September, L, B, S.
X. lucidata (*practica*)	Rather numerous throughout winter and spring, L, S.
X. venipunctata	Taken October, L.
X. cinerearia	Numerous throughout.
X. semisignata	Rather numerous throughout.
Adeixis griseata	Taken in September and October. Rather numerous November and December, S, edge of gumfield.
Epirrhanthis ustaria	Rather numerous throughout, L.
Selidosema pelurgata	Occasionally, B.
S. aristarcha	Occasionally, L. Numerous throughout, B and S.
S. productata	Very numerous, L, B, T.
S. indistincta	Occasionally, L and B.
S. leucelaea	Frequent January and February, L, B, T.
S. suavis	Very numerous, L, B, S.
S. rudiata	Occasionally, S.
S. fenerata	Very numerous during winter and spring. Frequent throughout.
S. adusta	December, B.
S. panagrata	Frequent, L, B.
S. dejectaria	Frequent, L, B.
Sestra flexata	Numerous November, December, B. Occasionally, L.

Gargaphia muriferata	Rather numerous throughout, L, B.
Azelina variabuis	Taken September and occasionally throughout, S.
A. gallaria	Taken September, B.
A. nelsonaria	Taken February, F.
Declana leptomera	Rather numerous during the winter, and occasionally throughout.
D. floccosa	Numerous November and December, L, T.
D. feredayi	Occasionally, L.
D. junctilinea	Occasionally, L.
Leptomeris rubraria	Abundant.

PYRALIDAE.

Crambus ramosellus	Numerous, L, S.
C. simplex	Rather numerous, L, S.
C. siriellus	Rather numerous December and January, S, on edge of gumfield.
C. apicellus	Rather numerous, L, S.
C. vittellus	Numerous, L, S.
C. flexuosellus	Numerous, L, S.
Diptychophora pyrsophanes	Several November, B.
D. chrysochyta	Rather numerous November and December, S.
D. interrupta	Several January, B.
D. lepidella	Rather numerous December and January, S, B, L.
D. leucoxantha	Taken October, B.
D. selenaea	Rather numerous January and February, B, L.
D. auriscriptella	Numerous November, December and January, S, B, L.
D. elaina	Numerous throughout season, L, S, B.
D. parorma	Not uncommon, S, L.
Gadira acerella	Taken January, L.
Nymphula nitens	Taken February, L.
Musotima aduncalis	Several throughout the season, L, B. Not uncommon.
M. nitidalis	Rather numerous, L, S, B.
Proternia philocapna	Numerous December, January and February, L. Occasionally, S.
Nesarcha hybrealis	Several September, L. January, B.
Mecyna maorialis	Rather numerous, F, February.
M. daiclealis	Several October, L. February, F and B. Not uncommon.
M. flavidalis	Rather numerous throughout.
Scoparia philerga	Numerous during the spring, B, S, L.
S. melliturga	Not numerous. Fairly common during the winter.
S. minusculalis	Taken October.

S. chimeria	Numerous, B, S, L, November, December, January.
S. dinodes	Numerous, T, also B and L, February, March.
S. acharis	Taken October, B.
S. ustimacula	Fairly common during winter and early spring. Several January.
S. periphanes	Several October, S and L.
S. colpota	Fairly frequent February, March, L and T.
S. submarginalis	Rather numerous January and February, L and S.
S. indistinctalis	Rather numerous January and February, L and S.
S. bisinualis	Rather numerous throughout the year, L. B, S.
S. chalicodes	Several March, April, L.
S. leptalea	Taken July, L.
S. epicomia	Taken October, B.
S. feredayi	Rather numerous November, December, January, B, S, L.
S. steropaea	Numerous October to March, B, S, L.
S. elaphra	Taken January, B.
S. sabulosella	Abundant October and November, S.
S. trivirgata	Single taken November and January, S.
S. aspidota	Several November, L.
S. luminatrix	Taken November, B.
S. octophora	Very numerous November, December and January, S.
Diplopseustis perieralis	Odd specimen throughout the winter. Rather numerous August, September, November, December, L, S, B.
Pyralis farinalis	Taken January. Fence.

Tortricidae.

Catamacta rureana	Taken November, B.
C. gavisana	Occasionally, B, S.
Capua plagiatana	Occasionally, S.
C. plinthoglypta	Taken November, S.
C. semiferana	Rather numerous, S.
C. intractana	Several, L.
Tortrix indigestana	Numerous, S, edge of gumfield, December.
T. postvittana	Occasionally, B.
T. orthocopa	Four specimens taken January, S.
T. conditana	Occasionally S.
T. alopecana	Several taken December, January, S.
T. excessana	Rather numerous, S, L.
T. flavescens	Several January, S, L.
T. scruposa	Rather numerous November and December, S, edge of gumfield.
T. torogramma	Frequent January and February, S.

Epalxiphora axenana	Rather numerous, S, T.
Ctenopseustis obliquana	Numerous.
Cnephasia incessana	Rather numerous November, B, occasionally throughout.
C. jactatana	Frequent throughout, L, B, S.
Spilonota dolopaea	Taken September.
S. parthenia	Rather numerous October, S.
S. zopherana	Very numerous, S.
S. ejectana	Very numerous, S.
S. macropetana	Several December, January, S.
Eucosma querula	Several, S.
Bactra noteraula	Rather numerous January, February, L.
Laspeyresia pomonella	Occasionally, L. Larva very numerous.

TINEIDAE.

Megacraspedus calamogona	Single taken October and January.
Aristotelia paradesma	Two taken January, L.
Phthorimaea melanoplintha	Taken March, L.
P. operculella	Several March, April, L.
Endrosis lacteella	Frequent in house.
Borkhausenia armigerella	Rather numerous October, November, S.
B. basella	Very numerous October, November, B.
B. chloradelpha	Rather numerous, October, S.
B. ancogramma	Rather numerous November, December, January, S and B.
B. innotella	Rather numerous November, December, S.
B. plagiatella	October, S.
B. pseudospretella	At times in house.
Leptocroca scholaea	Very numerous December, January, S, B.
Compsistis bifaciella	Occasionally clearings, B, November, December, January.
Gymnobathra hyetodes	Rather numerous January, February, S. Occasionally, B.
G. flavidella	Numerous December, January, February, B, occasionally, L.
G. parca	Occasionally November, December, S.
G. calliploca	Several January, February, B.
G. bryaula	Fairly numerous January, February, T. ♀ Much more numerous than ♂.
G. tholodella	
Izatha peroneanella	Fairly numerous December, January, February, L, T, B.
I. picarella	Taken November, L.
I. epiphanes	Rather numerous November, December, L. S, B.
I. prasophyta	Occasionally December, January, B, T.
I. balanophora	Several January, S.
Trachypepla euryleucota	Several February, L, F.
T. amphileuca	Two taken November, S.

T. hieropis	Taken November, S.
T. galaxias	Several October, November, S.
T. contritella	Taken November, S.
T. aspidephora	Several January, February, B, T.
T. indolescens	Several February, L.
T. eumenopa	Taken November, B.
Euprionocera notabilis	Single specimens taken August and February, L.
Barea dinocosma	Rather numerous October, November, B.
B. confusella	Frequent December, January, L, S.
Eulechria zophoessa	Several.
Cryptolechia liochroa	Several November, B.
C. rhodobapta	Several November, B.
Phycomorpha metachrysa	Taken December, B.
Isonomeutis restincta	Several November, December, January, B.
Carposina adreptella	Taken October, B.
C. charaxias	Several taken December, January and February, S, B.
C. eriphylla	Several June, L.
C. gonosemana	February, T.
C. iophaea	Taken March, B.
Vanicela disjunctella	Occasionally in spring, L. Rather numerous January, February, B.
Stathmopoda caminora	Rather numerous October to March, B, L.
S. phlegyra	Rather numerous October to January, B.
S. skelloni	Rather numerous October to January, B, L.
S. mysteriastis	Taken February, L.
Pyroderces apparitella	Rather frequent November, December, January, L. Occasionally, B.
Thectophila acmotypa ?	Taken March, B.
Batrachedra eucola	Taken February, S.
Heliostibes atychioides	Taken December, B.
Simaethis combinatana	Taken January, B.
Choreutis bjerkandrella	Occasionally, L, once, B. December, January and February.
Glyphipteryx transversella	Taken December, B.
G. iocheaera	Taken December, B.
G. leptosema	Taken November, B.
G. zelota	Occasionally December, January, B.
Elachista gerasmia	Several November, December, January, S.
Parectopa citharoda	Taken November, B.
Gracilaria linearis	Numerous November, December, January, S, B.
G. chrysitis	Occasionally November, December. Rather numerous January, February, B.
G. chalcodelta	Taken March, B.
Cadmogenes literata	Frequent December, January, B.
Orthenches glypharcha	Taken October, B.
Plutella sera	Rather frequent August, September, L.

P. maculipennis	Rather numerous January, February, March, L, S.
Opogona omoscopa	Numerous throughout the year, L.
Eugennaea laquearia	Taken, December, B.
Erechthias terminella	Rather frequent September, L. Occasionally January, February, B.
E. exospila	Several January, February, B.
E. hemiclistra	Occasionally November, December, January, B.
Hectacma chionodira	Rather frequent September to February, B, L.
Endophthora omogramma	Several February, B, T.
E. pallacopis	Taken March, T.
Crypsitricha pharotoma	Occasionally October, L. February, T.
C. mesotypa	Rather frequent January, February, T, B
C. roseata	Taken September, L.
Archyala paraglypta	Several March, L.
Sagephora felix	Several February, T, B.
S. phortegella	Rather frequent December, January, February, B, S.
Monopis ethelella	Numerous throughout the year, L, S.
Prothinodes grammocosma	Frequent September, October, B. Occasionally January, February.
Trithamnora certella	Rather numerous November, December, B.
Lysiphragma epixyla	Taken March, T.
Lindera tessellatella	Taken January.
Mallobathra homalopa	Taken November, B.
Coleophora spissicornis	Rather numerous November, December, S, L.

HEPIALIDAE.

Hepialus virescens	Occasionally in house.
Porina enysii	Several January, February, I·
P. signata	Taken October, L.

APPENDIX.

THE HUTTON MEMORIAL MEDAL AND RESEARCH FUND.

Regulations under which the Hutton Memorial Medal shall be awarded and the Research Fund administered.

1. Unless in exceptional circumstances, the Hutton Memorial Medal shall be awarded not oftener than once in every three years; and in no case shall any medal be awarded unless, in the opinion of the Board, some contribution really deserving of the honour has been made.

2. The medal shall not be awarded for any research published previous to the 31st December, 1906.

3. The research for which the medal is awarded must have a distinct bearing on New Zealand zoology, botany, or geology.

4. The medal shall be awarded only to those who have received the greater part of their education in New Zealand or who have resided in New Zealand for not less than ten years.

5. Whenever possible, the medal shall be presented in some public manner.

6. The Board of Governors may, at any annual meeting, make grants from the accrued interest of the fund to any person, society, or committee for the encouragement of research in New Zealand zoology, botany, or geology.

7. Applications for such grants shall be made to the Board before the 30th September.

8. In making such grants the Board of Governors shall give preference to such persons as are defined in regulation 4.

9. The recipients of such grants shall report to the Board before the 31st December in the year following, showing in a general way how the grant has been expended and what progress has been made with the research.

10. The results of researches aided by grants from the fund shall, where possible, be published in New Zealand.

11. The Board of Governors may from time to time amend or alter the regulations, such amendments or alterations being in all cases in conformity with resolutions 1 to 4.

Award of the Hutton Memorial Medal.

1911. Professor W. B. Benham, D.Sc., F.R.S., University of Otago—For researches in New Zealand zoology.

1914. Dr. L. Cockayne, F.L.S., F.R.S.—For researches in the ecology of New Zealand plants.

1917. Professor P. Marshall, M.A., D.Sc.—For researches in New Zealand geology.

1920. Rev. John E. Holloway, D.Sc.—For researches in New Zealand pteridophytic botany.

1923. J. Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst.—For researches in geology.

1926. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S., F.N.Z.Inst.—For his continuous researches on the Amphipodous Crustacea of the Southern Hemisphere.

1929. Mr. G. V. Hudson, F.E.S., F.N.Z.Inst.—For research in Entomology.

GRANT FROM THE HUTTON MEMORIAL RESEARCH FUND.

1919. Miss M. K. Mestayer £10, for work on the New Zealand Mollusca.

1923. Professor P. Marshall, M.A., D.Sc., F.N.Z.Inst.—£40, for study of Upper Cretaceous ammonites of New Zealand.

1927. Miss M. K. Mestayer £30, for research on Brachiopoda and Mollusca.

1928. Dr. C. Chilton £50, for research on New Zealand and Antarctic Crustacea.

1928. Mr. J. H. Findlay £10, for research on New Zealand Mollusca.

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TRANSACTIONS

AND

PROCEEDINGS

OF THE

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NEW ZEALAND INSTITUTE.

NOTICE TO MEMBERS.

THE publications of the New Zealand Institute consist of—

1. Transactions, a yearly volume of scientific papers read before the local Institutes. This volume is of royal-octavo size.

2. Proceedings, containing report of the annual meeting of the Board of Governors of the New Zealand Institute, list of members, &c. The *Proceedings* are incorporated with the quarterly numbers of *Transactions* supplied to members.

3. Bulletins. Under this title papers are issued from time to time which for some reason it is not possible to include in the yearly volume of *Transactions*. The bulletins are of the same size and style as the *Transactions*, but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

LIBRARY PRIVILEGES OF MEMBERS.—Upon application by any member to the Librarian of the New Zealand Institute or of any of the affiliated Societies such works as he desires to consult which are in those libraries will be forwarded to him, subject to the rules under which they are issued by the Institute or the Societies. The borrower will be required to pay for the carriage of the books. For a list of the serial publications received by the Library of the New Zealand Institute, see vol. 60, pp. 638-650.

ADDRESSES OF MEMBERS.—Members are requested to notify the Secretary of any change of address, so that the same may be noted in the List of Members.

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